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ORIENTATION-ERROR ACCIDENTS IN REGULAR ARMY AIRCRAFT  
DURING FISCAL YEAR 1968: RELATIVE INCIDENCE AND COST

Jorma I. Niven, W. Carroll Hixson, and Emil Spezia



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<p>This report is the second in a longitudinal series of reports dealing with the pilot disorientation/vertigo accident problem in Army fixed wing and rotary wing flight operations. Incidence and cost data presented for fiscal year 1968 include a total of 75 major and minor orientation-error accidents (26 of which were fatal), resulting in 91 fatalities, 75 nonfatal injuries, and an over-all aircraft damage cost of \$12,381,805. The contribution of rotary wing accidents to these totals was 66 accidents (21 of which were fatal), resulting in 80 fatalities, 70 nonfatal injuries, and an over-all aircraft damage cost of \$9,077,065.</p>		

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## SUMMARY PAGE

### THE PROBLEM

From the military mission viewpoint, the amount of research effort to be expended on the solution of a given aviation medicine problem must be keyed to the operational cost of the problem. Therefore, a necessary first step in the development of a solution is the assimilation of data that define the magnitude of the problem. Though orientation-error accidents involving pilot disorientation and vertigo have been long recognized to exist, little quantitative data are available to describe the actual incidence and cost of such accidents in Army aviation.

### FINDINGS

To initiate the action necessary to establish the magnitude of the orientation-error problem in Army aviation, an interservice research program was organized under the joint sponsorship of the U. S. Army Aeromedical Research Laboratory, the U. S. Army Board for Aviation Accident Research, and the Naval Aerospace Medical Research Laboratory. The first step was the construction of an operational definition of an orientation-error accident. The assimilation of data pertaining to the incidence and cause of such accidents and their actual and relative costs in terms of fatalities, injuries, and aircraft damage was then set as the working objective of the program. Accordingly, the decision was made to implement a five-year longitudinal study of all major and minor orientation-error accidents involving Regular Army flight operations beginning with fiscal year 1967. Findings are being summarized on a fiscal-year basis in three separate lines of reports: The first line is devoted to defining the over-all magnitude of the orientation-error problem in all aircraft types; the second line to the presentation of similar incidence and cost data for accidents involving only the UH-1 aircraft, the predominant rotary wing aircraft in the Army inventory; and the third line to the description of the various causal factors found to be present in the major UH-1 orientation-error accidents.

This specific report is the second in the series dealing with the over-all magnitude of the orientation-error problem in all aircraft types. Incidence and cost data are presented for all Regular Army major and minor orientation-error accidents detected in the search of the fiscal year 1968 accident files. Separate and totalized statistical data are provided for fixed wing and rotary wing aircraft as well as for accidents occurring in Vietnam and those occurring elsewhere.

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The findings in this report are not to be construed as an official Department of the Army position, unless so designated by other authorized documents.

## ACKNOWLEDGMENTS

The authors wish to thank Colonel R. W. Bailey, MSC, USA, Commanding Officer, U. S. Army Aeromedical Research Laboratory, for his direction and assistance in the initial setup and structure of the project and for his continued support of its research objectives. The authors wish to thank also the director of the U. S. Army Board for Aviation Accident Research and his data processing staff for making the master accident files available for analysis and for compiling the all-accident and pilot-error accident statistics included in this specific report. In addition, we acknowledge the assistance of Mrs. Linda Pearce of the Naval Aerospace Medical Research Laboratory (NAMRL) in the conduct of the orientation-error accident analysis program and to thank her for the sustained, always cheerful, working support she has devoted to the accomplishment of the project objectives. Other NAMRL personnel whom the authors wish to thank include Mr. A. N. Dennis and Mr. C. A. Lowery, both of the Bionics Branch, who assisted in the compilation and graphical layout of the data; Miss E. C. Marques of the Biostatistics Branch and her staff who checked the statistical calculations; and Mr. R. C. Barrett of the Visual Aids Branch who photographed the report figures.

## LIST OF TABLES

	Page
Table I. All Accident Types: All Aircraft . . . . .	4
Table II. All Accident Types: Fixed Wing Aircraft . . . . .	5
Table III. All Accident Types: Rotary Wing Aircraft . . . . .	6
Table IV. All Accident Types: Ratio of RW to FW Data . . . . .	7
Table V. Pilot-Error Accidents Only: All Aircraft . . . . .	16
Table VI. Pilot-Error Accidents Only: Fixed Wing Aircraft . . . . .	16
Table VII. Pilot-Error Accidents Only: Rotary Wing Aircraft . . . . .	17
Table VIII. Pilot-Error Accidents Only: Ratio of RW to FW Data . . . . .	17
Table IX. Orientation-Error Accidents Only: All Aircraft. . . . .	23
Table X. Orientation-Error Accidents Only: Fixed Wing Aircraft . . . . .	23
Table XI. Orientation-Error Accidents Only: Rotary Wing Aircraft . . . . .	24
Table XII. Orientation-Error Accidents Only: Ratio of RW to FW Data . . . . .	24

## LIST OF FIGURES

Figure 1A. Weighting Factor: Total Aircraft Flying Hours . . . . .	9
Figure 1B. Weighting Factor: Total Aircraft Landings . . . . .	9
Figure 2. All Accident Types: Incidence of Major and Minor Accidents . . . . .	10
Figure 3A. All Accident Types: Total Number of Fatal Accidents . . . . .	11
Figure 3B. All Accident Types: Total Number of Fatalities . . . . .	11
Figure 3C. All Accident Types: Total Number of Nonfatal Injuries . . . . .	11
Figure 3D. All Accident Types: Total Aircraft Dollar Damage . . . . .	11
Figure 4A. All Accident Types: Accident Rate per 100,000 Hours . . . . .	12
Figure 4B. All Accident Types: Accident Rate per 100,000 Landings . . . . .	12
Figure 5A. All Accident Types: Ratio of VN-to-US Accidents; Equal Flying Hours. . . . .	13
Figure 5B. All Accident Types: Ratio of VN-to-US Accidents; Equal Landings. . . . .	13
Figure 6A. All Accident Types: Ratio of RW-to-FW Accidents; Equal Flying Hours. . . . .	14
Figure 6B. All Accident Types: Ratio of RW-to-FW Accidents; Equal Landings. . . . .	14
Figure 7. Pilot-Error Accidents Only: Incidence of Major and Minor Accidents . . . . .	18

## PROCEDURE

A basic requirement for the commencement of this study was a workable definition of the class of accidents to be defined as involving orientation error. The reader is referred to previous reports (refs. 1-3) for a comprehensive definition and discussion of its rationale. Briefly, orientation is considered to involve the correct determination of the dynamic position and attitude of an aircraft in three-dimensional space. The key word here is dynamic, which implies that full knowledge of the motion as well as static attitude and position is required to define its instantaneous spatial orientation. Accordingly, a pilot is considered to have made an orientation error whenever his perception of the motion and attitude of his aircraft differs from the true motion or altitude; i.e., the true orientation of the aircraft. An orientation-error accident is then defined as one that occurs as a result of an incorrect control or power action taken by a pilot (or a correct action not taken) due to his incorrect perception of the true orientation of his aircraft.

With this definition of orientation-error accidents serving as a classification reference, an experienced classifier read all briefs in the USABAAR master accident files and selected all major and minor accidents of this type occurring during fiscal year 1968. For redundancy, the entire accident files were also searched by sifting the coded summaries that USABAAR prepares for each accident for a wide range of indicator terms.

The authors then reviewed the accident briefs independently for the purpose of establishing whether or not an orientation-error accident classification would result. In addition, the comprehensive master file on each suspect accident was obtained and reviewed. Whenever there was serious question as to the contribution of orientation error to the accident or where equally weighted alternative causal factors were present, then the accident was not included in the classification. The net effect of this policy is to give a conservative estimate of the magnitude of the orientation-error accident problem.

## RESULTS AND DISCUSSION

The reader is referred to the first report (ref. 1) of this series for details pertaining to the format selected to summarize the accident statistics on a yearly basis. Briefly, the format is keyed to providing a cursory review of the incidence and costs of aircraft accidents in general so as to place better perspective on the actual operational magnitude of the orientation-error accident problem. To establish this background, the first section to follow is devoted to describing the over-all cost of all Regular Army aircraft accidents, regardless of type or location, that occurred during fiscal year 1968. In a second section, equivalent data in a nearly identical format are presented to separately identify those accidents in the first section that were classified by USABAAR as involving one or more pilot-error factors. Cost statistics pertaining to only orientation-error accidents are then presented in a third section. By using these three sets of data as independent references, it then becomes possible to establish some quantitative insight into the relative, as well as actual, cost of orientation-error accidents in Regular Army flight operations. Selected comparative relationships of this type are presented in the last section of the report.



For the reader's convenience in making a point-by-point comparison of fiscal year 1968 statistics with those for other fiscal years of the study, the layout and numbering of tables and figures in this report follow identically those presented previously (ref. 1).

## ALL TYPES OF AIRCRAFT ACCIDENTS

The data presented in this section describe the incidence and cost of all major and minor aircraft accidents involving all Regular Army flight operations during fiscal year 1968. Separate data groupings are provided for accidents involving only fixed wing (FW) aircraft, only rotary wing (RW) aircraft, and their combined total. In addition, for each of these three statistical groupings, the data are divided into those accidents that occurred in Vietnam, those accidents that occurred elsewhere, and their combined total. Since the vast majority of the accidents that do not occur in Vietnam (VN) take place within the continental limits of the United States, the abbreviation US is arbitrarily used to denote all accidents that do not occur in Vietnam. It should be realized then that the US data grouping will include a small number of accidents that may have occurred, for example, in Europe, Africa, or elsewhere. A second point to be stressed is that the VN data pertain strictly to accidents, not losses due to enemy action.

In the interpretation of the accident statistics to follow, it becomes possible to compare FW and RW accident incidence or VN and US accident incidence only when some common measures of aircraft utilization are selected as weighting factors. To establish such comparative references, percent aircraft inventory, total flying hours, and total aircraft landings are used as basic weighting data in this report. These data, as well as the incidence and cost statistics presented in this section, are summarized in Tables I through IV. Table I pertains to all accidents in all types of aircraft, Table II to only FW accidents, and Table III to only RW accidents. The ratio of the RW data in Table III to the FW data in Table II is summarized in Table IV.

When the aircraft inventory data listed in Tables I through III are examined, two points become obvious. First, as listed in Table I, the average number of aircraft operating out of VN during fiscal year 1968 was less than the number of aircraft operating out of US. In relative terms, 40.18 percent of the total inventory were stationed in VN as compared to 59.82 percent stationed in US, resulting in a VN/US inventory ratio of 0.67 to 1 for all aircraft types. The second point, derived from Tables II and III, is that RW aircraft remained the predominant aircraft in the Regular Army inventory. Of the total number of aircraft, 78.85 percent were of the RW type and 21.15 percent of the FW type, thus resulting in a RW/FW inventory ratio of 3.73 to 1. For both types of aircraft, the VN/US inventory ratio was less than unity; i.e., 0.45 to 1 for FW and 0.74 to 1 for RW. Accordingly, in terms of average aircraft inventory, the majority of the aircraft operated in the US and the majority of the aircraft were of the RW type.

A similar, though smaller, US predominance results when total aircraft flight hours are used as a weighting factor. These data are plotted in Figure 1A for both aircraft types and for both geographical references. The visual interpretation of this graph, as well as the majority of the remaining graphs in the report, is as follows: The group of

TABLE I				
FISCAL YEAR 1968 DATA				
ALL ACCIDENT TYPES		ALL AIRCRAFT		
ACCIDENT INDEX	U.S. ACCIDENTS	VIET NAM ACCIDENTS	ALL ACCIDENTS	VN to US RATIO
Major Accidents	246	739	985	3.00
Minor Accidents	26	31	57	1.19
Total Accidents	272	770	1,042	2.83
Aircraft Inventory - Percent Total	59.82	40.18	100.0	0.67
Total Flying Hours	2,372,739	2,751,623	5,124,362	1.16
Total Landings	9,105,321	6,582,735	15,688,056	0.72
Major Accidents per 100,000 Hours	10.37	26.86	19.22	2.59
Minor Accidents per 100,000 Hours	1.10	1.13	1.11	1.03
Total Accidents per 100,000 Hours	11.46	27.98	20.33	2.44
Major Accidents per 100,000 Landings	2.70	11.23	6.28	4.16
Minor Accidents per 100,000 Landings	0.29	0.47	0.36	1.62
Total Accidents per 100,000 Landings	2.99	11.70	6.64	3.91
Total Dollar Cost	16,766,586	99,471,086	116,237,672	5.93
Average Dollar Cost per Accident	61,642	129,183	111,552	2.10
Total Fatalities	65	364	429	5.60
Average Fatalities per Accident	0.24	0.47	0.41	1.96
Fatal Accidents - Number	33	105	138	3.18
Fatal Accidents - Percent	12.13	13.64	13.24	1.12
Average Fatalities per Fatal Accident	1.97	3.47	3.11	1.76
Total Injuries (Nonfatal)	114	885	999	7.76
Average Injuries per Accident	0.42	1.15	0.96	2.74

TABLE II  
FISCAL YEAR 1968 DATA

ALL ACCIDENT TYPES		FIXED WING AIRCRAFT ONLY		
ACCIDENT INDEX	U. S. ACCIDENTS	VIET NAM ACCIDENTS	ALL ACCIDENTS	VN to US RATIO
Major Accidents	53	86	139	1.62
Minor Accidents	8	3	11	0.38
Total Accidents	61	89	150	1.46
Aircraft Inventory - Percent Total	14.56	6.59	21.15	0.45
Total Flying Hours	497,306	512,464	1,009,770	1.03
Total Landings	1,169,305	387,514	1,556,819	0.33
Major Accidents per 100,000 Hours	10.66	16.78	13.77	1.57
Minor Accidents per 100,000 Hours	1.61	0.59	1.09	0.37
Total Accidents per 100,000 Hours	12.27	17.37	14.85	1.42
Major Accidents per 100,000 Landings	4.53	22.19	8.93	4.90
Minor Accidents per 100,000 Landings	0.68	0.77	0.71	1.13
Total Accidents per 100,000 Landings	5.22	22.97	9.64	4.40
Total Dollar Cost	3,705,924	10,899,382	14,605,306	2.94
Average Dollar Cost per Accident	60,753	122,465	97,369	2.02
Total Fatalities	18	30	48	1.67
Average Fatalities per Accident	0.30	0.34	0.32	1.13
Fatal Accidents - Number	8	13	21	1.62
Fatal Accidents - Percent	13.11	14.61	14.00	1.11
Average Fatalities per Fatal Accident	2.25	2.31	2.29	1.03
Total Injuries (Nonfatal)	17	42	59	2.47
Average Injuries per Accident	0.28	0.47	0.39	1.68

TABLE III  
FISCAL YEAR 1968 DATA

ALL ACCIDENT TYPES

ROTARY WING AIRCRAFT ONLY

ACCIDENT INDEX	U.S. ACCIDENTS	VIET NAM ACCIDENTS	ALL ACCIDENTS	VN to US RATIO
Major Accidents	193	653	846	3.38
Minor Accidents	18	28	46	1.56
Total Accidents	211	681	892	3.23
Aircraft Inventory - Percent Total	45.26	33.59	78.85	0.74
Total Flying Hours	1,875,433	2,239,159	4,114,592	1.19
Total Landings	7,936,016	6,195,221	14,131,237	0.78
Major Accidents per 100,000 Hours	10.29	29.16	20.56	2.83
Minor Accidents per 100,000 Hours	0.96	1.25	1.12	1.30
Total Accidents per 100,000 Hours	11.25	30.41	21.68	2.70
Major Accidents per 100,000 Landings	2.43	10.54	5.99	4.34
Minor Accidents per 100,000 Landings	0.23	0.45	0.33	1.96
Total Accidents per 100,000 Landings	2.66	10.99	6.31	4.13
Total Dollar Cost	13,060,662	88,571,704	101,632,366	6.78
Average Dollar Cost per Accident	61,899	130,061	113,938	2.10
Total Fatalities	47	334	381	7.11
Average Fatalities per Accident	0.22	0.49	0.43	2.23
Fatal Accidents - Number	25	92	117	3.68
Fatal Accidents - Percent	11.85	13.51	13.12	1.14
Average Fatalities per Fatal Accident	1.88	3.63	3.26	1.93
Total Injuries (Nonfatal)	97	843	940	8.69
Average Injuries per Accident	0.46	1.24	1.05	2.70

TABLE IV			
FISCAL YEAR 1968 DATA			
ALL ACCIDENT TYPES		RATIO OF RW TO FW DATA	
ACCIDENT INDEX	U.S. ACCIDENTS	VIET NAM ACCIDENTS	ALL ACCIDENTS
Major Accidents	3.64	7.59	6.09
Minor Accidents	2.25	9.33	4.18
Total Accidents	3.46	7.65	5.95
Aircraft Inventory - Percent Total	3.11	5.10	3.73
Total Flying Hours	3.77	4.37	4.07
Total Landings	6.79	15.99	9.08
Major Accidents per 100,000 Hours	0.97	1.74	1.49
Minor Accidents per 100,000 Hours	0.60	2.12	1.03
Total Accidents per 100,000 Hours	0.92	1.75	1.46
Major Accidents per 100,000 Landings	0.54	0.47	0.67
Minor Accidents per 100,000 Landings	0.34	0.58	0.46
Total Accidents per 100,000 Landings	0.51	0.48	0.65
Total Dollar Cost	3.52	8.13	6.96
Average Dollar Cost per Accident	1.02	1.06	1.17
Total Fatalities	2.61	11.13	7.94
Average Fatalities per Accident	0.73	1.44	1.34
Fatal Accidents - Number	3.12	7.08	5.57
Fatal Accidents - Percent	0.90	0.92	0.94
Average Fatalities per Fatal Accident	0.84	1.57	1.43
Total Injuries (Nonfatal)	5.71	20.07	15.93
Average Injuries per Accident	1.64	2.64	2.69

three bars drawn at the left in Figure 1A pertain to the total flying hours of all FW aircraft. Within this three-bar group, the right-hand bar, marked VN, plots the total number of FW hours flown in Vietnam; the left-hand bar, marked US, plots the total number of hours flown elsewhere (primarily in the United States); and the central bar of this group, marked ALL, is a plot of the direct sum of the adjacent VN and US data. The interpretation of the three-bar group drawn at the right in Figure 1A follows identically except that total hours of RW aircraft are involved. Similarly, the three-bar group at the center of the figure describes the total hours of both types of aircraft, with the depicted data representing the direct sum of the adjacent FW and RW data.

The data of Figure 1A and Table I thus show that Army aircraft were flown a total of 5,124,362 hours during fiscal year 1968 of which 2,751,623 hours were flown in VN and 2,372,739 hours elsewhere. This results in a VN/US total hours ratio of 1.16 to 1, indicating approximately equal usage in each location. The total hours data of Tables II and III show that the VN/US total hours ratio was 1.03 to 1 for FW aircraft and 1.19 to 1 for RW aircraft. It should be observed also that the total hours flown in RW aircraft considerably exceeded those flown in FW aircraft. That is, the over-all RW/FW total hours ratio was 4.07 to 1 (see Table IV).

Weighting-factor data with total aircraft landings as reference are plotted in Figure 1B. In terms of landings, the utilization of both FW and RW aircraft was greater in the US; i.e., the VN/US total landings ratio was 0.33 to 1 for FW aircraft and 0.78 to 1 for RW aircraft. As would be expected due to the short-range, multiple-hop mission of helicopters, the total landings of RW aircraft exceeded those of FW aircraft, with the over-all RW/FW landing ratio being 9.08 to 1.

With these background data as reference, it becomes possible to make a weighted interpretation of the raw accident data presented in Tables I through IV. Selected excerpts from these data are plotted in Figures 2 and 3. The numerical incidence of all major and minor aircraft accidents, regardless of type or causal factor, is plotted in Figure 2. The cost of these accidents as measured by the number of fatal accidents, number of fatalities, number of nonfatal injuries, and aircraft dollar damage is outlined in Figures 3A through 3D, respectively.

In terms of the over-all aircraft accident problem, these data show that during fiscal year 1968, there were a total of 1,042 accidents, 138 of which were fatal; there resulted 429 fatalities, 999 nonfatal injuries, and a total aircraft damage cost of \$116,237,672. The FW aircraft contribution to these totals was 150 accidents (21 of which were fatal), resulting in 48 fatalities, 59 nonfatal injuries, and a total aircraft damage cost of \$14,605,306. The RW data show 892 accidents (117 of which were fatal), resulting in 381 fatalities, 940 nonfatal injuries, and a total aircraft damage cost of \$101,632,366. For FW aircraft, the incidence of accidents in VN was 1.46 times the incidence elsewhere; for RW aircraft, the VN incidence was 3.23 times the incidence elsewhere.

A higher accident incidence was not the only consequence of VN operations. As shown in Figure 3, the relative cost of VN accidents in terms of personnel and aircraft

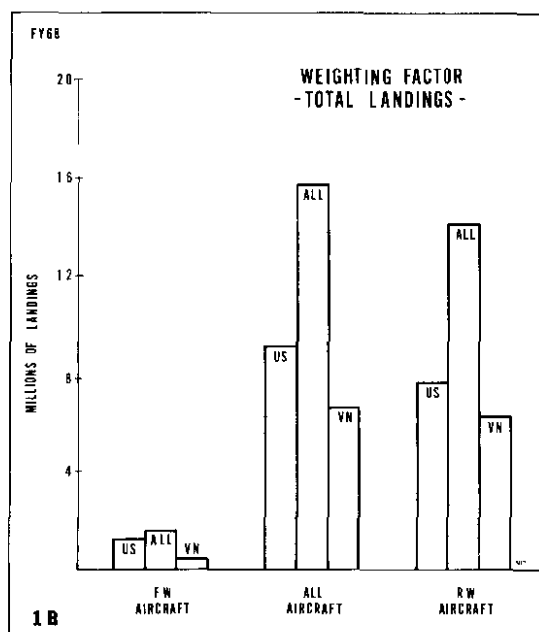
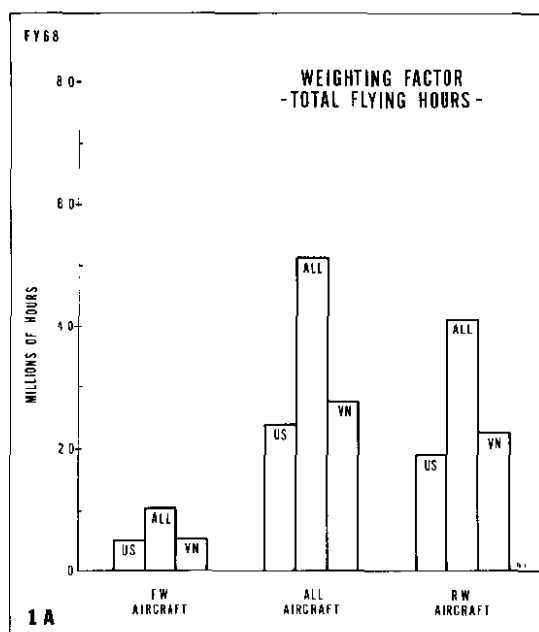


Figure 1

Total flying hours (A) and total landings (B) by aircraft type and location during fiscal year 1968. In A, the three bars at the left pertain to fixed wing (FW) aircraft, with the VN bar indicating total FW hours flown in Vietnam; the US bar, total hours flown elsewhere (primarily in the United States); and the ALL bar, the sum of the adjacent VN/US data. The layout of the three bars at the extreme right is identical, but pertains to rotary wing (RW) aircraft hours. The three central bars summarize the FW and RW data and represent total hours of all aircraft types. Total RW hours were 4.07 times the total FW hours while total RW landings were 9.08 times the total FW landings. The hours flown in VN and US were approximately the same for both aircraft types. More landings were made in the US, however, particularly in the case of FW aircraft.

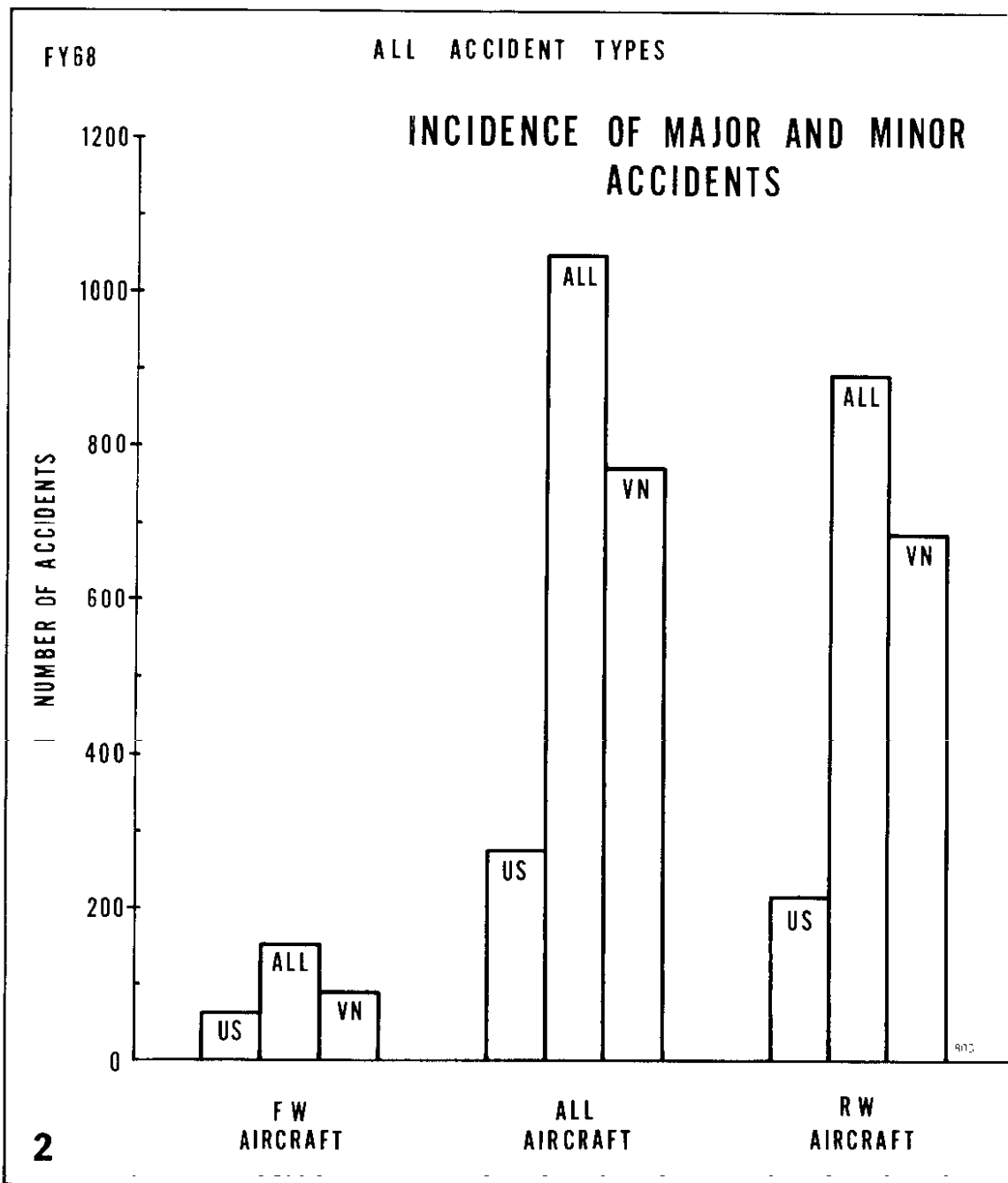


Figure 2

All Accident Types: Total number of major and minor aircraft accidents in all types that occurred in Regular Army flight operations during fiscal year 1968. Total number of FW accidents is shown by the center bar at the left, with the adjacent VN and US bars indicating location of the accidents. Data for RW accidents are at the extreme right, with total accidents of both aircraft types summarized in the center. The VN data presented throughout this report pertain to aircraft accidents, not losses due to enemy action, that occurred in Vietnam. Considering all aircraft, the incidence of accidents in VN was 2.83 times greater than the incidence elsewhere.



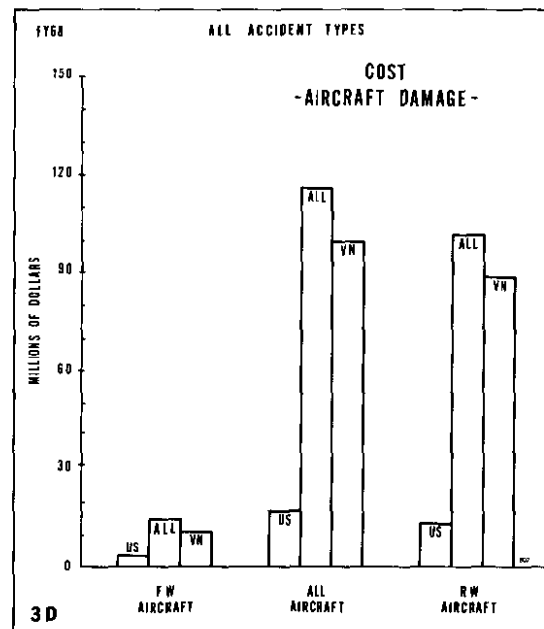
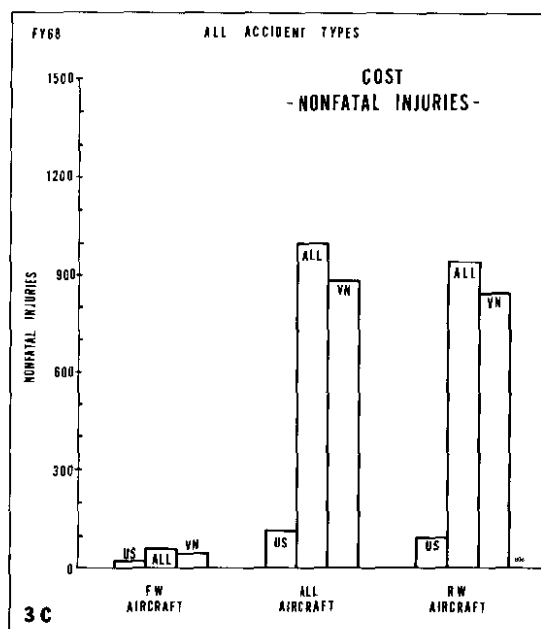
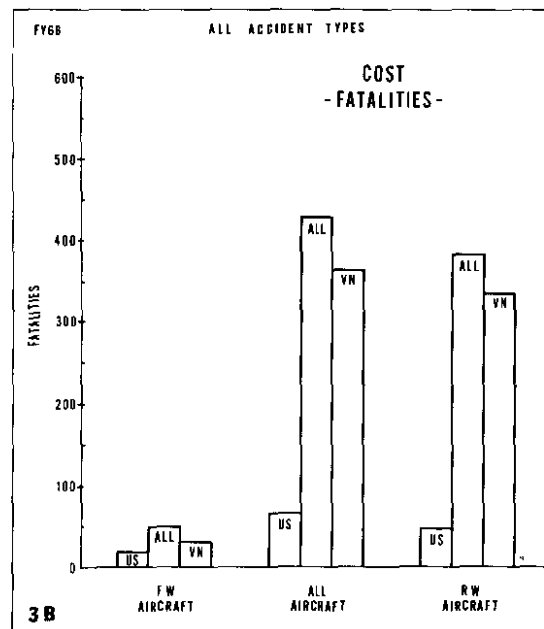
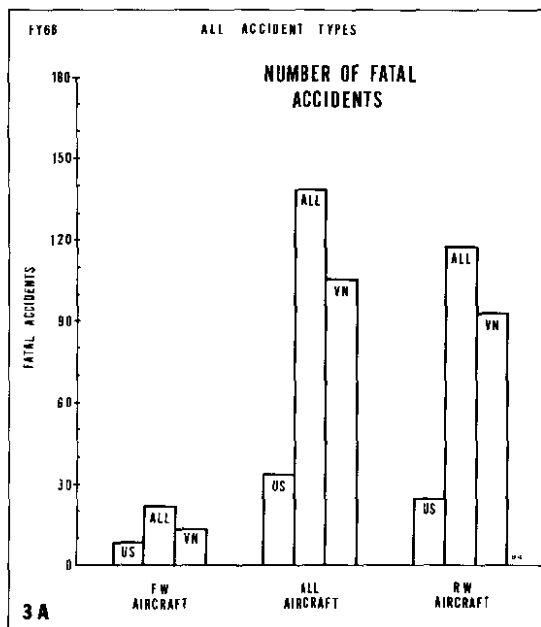


Figure 3

All Accident Types: Total number of fatal accidents (A), total number of fatalities (B), total number of nonfatal injuries (C), and total dollar cost of resulting aircraft damage (D) for both RW and FW aircraft and for both VN and US locations. In all cases, the greatest loss occurred in VN.

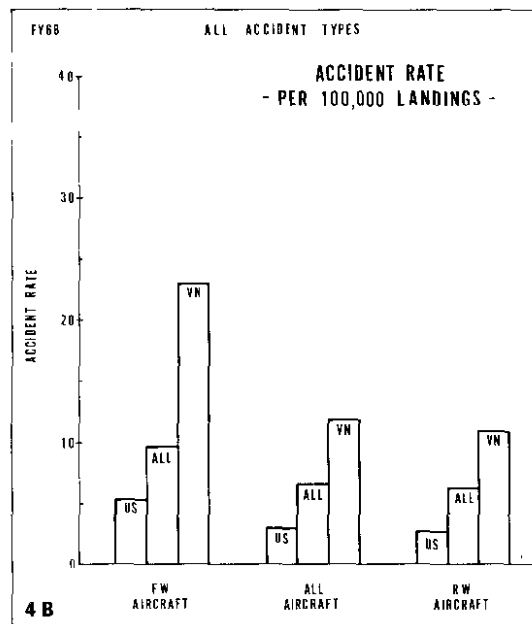
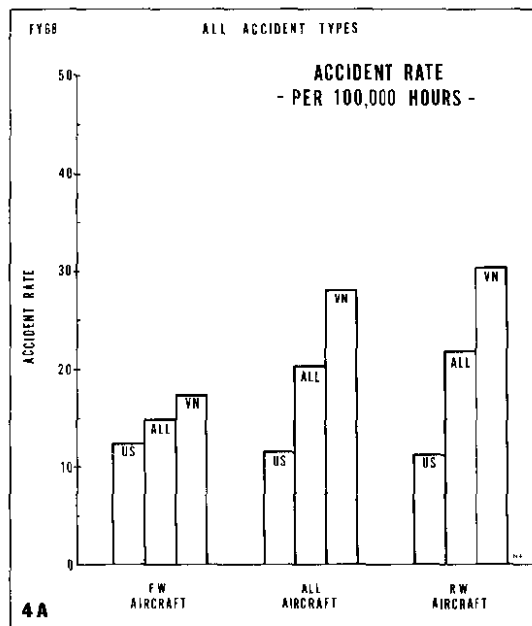


Figure 4

All Accident Types: Normalized incidence data showing average number of accidents per 100,000 flying hours (A) and average number of accidents per 100,000 landings (B). For all FW aircraft, the rates were 14.85 and 9.64 accidents per 100,000 hours and per 100,000 landings, respectively. For all RW aircraft, the rates were 21.68 and 6.31 accidents per 100,000 hours and per 100,000 landings, respectively. In all cases, the accident rates were greatest in VN.

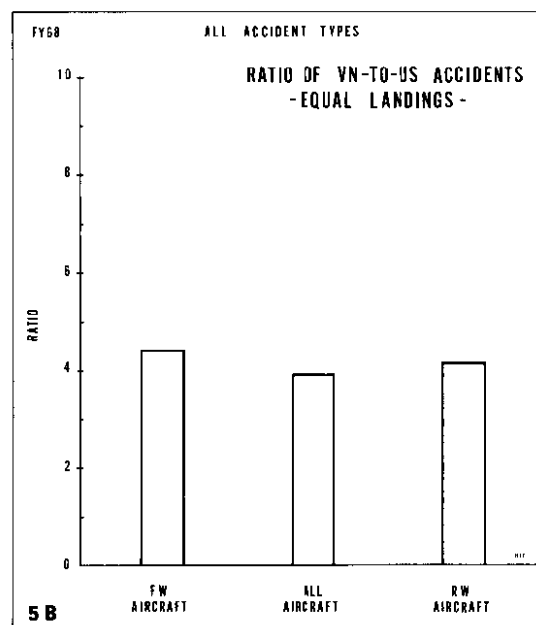
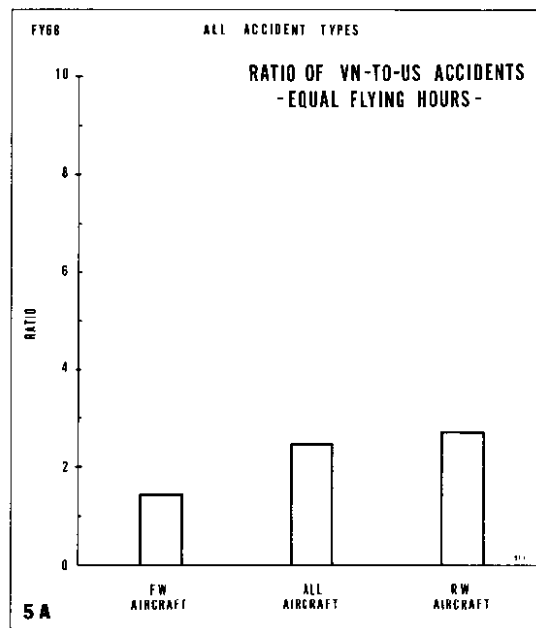


Figure 5

All Accident Types: Normalized ratio of accidents occurring in VN to accidents occurring in US based on equal flying hours (A) and equal landings (B) for both types of aircraft. Based on equal hours, the accident rates in VN for FW and RW aircraft were 1.42 and 2.70 times greater, respectively, than the US rates. Based on equal landings, the accident rates in VN for FW and RW aircraft were 4.40 and 4.13 times greater, respectively, than the US rates.

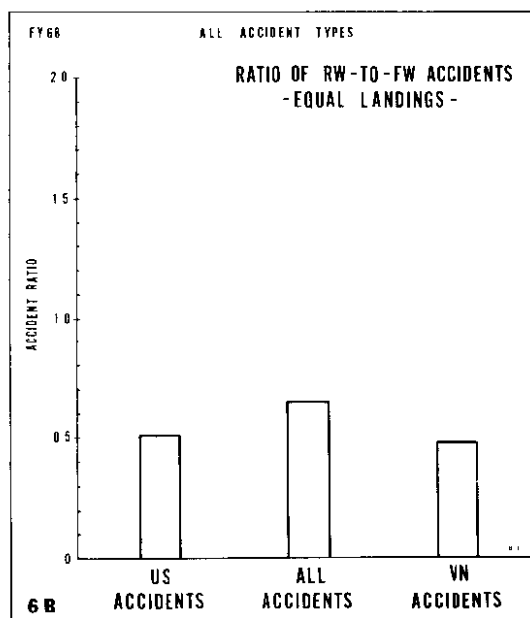
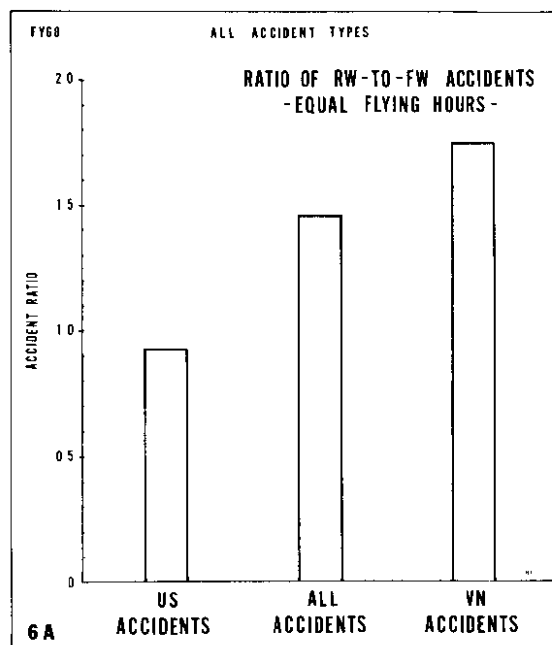


Figure 6

All Accident Types: Normalized ratio of accidents occurring in RW aircraft to accidents occurring in FW aircraft based on equal flying hours (A) and equal landings (B) for both locations. When equal hours served as a reference (A), the probability of an accident occurring in the US was about the same for both aircraft types. In VN, the RW accident rate was almost 1.75 times greater than the FW accident rate. When equal landings were used as a reference (B) the probability of an accident occurring in a RW aircraft was less than that for FW aircraft. This ratio is about the same whether the accident occurred in VN or elsewhere.

damage exceeded that of US accidents by a considerable amount. That is, for accidents involving all types of aircraft, there were 3.18 times as many fatal accidents in VN as there were elsewhere, 5.60 times as many fatalities, and 7.76 times as many nonfatal injuries. In addition, the average dollar cost of a VN accident was 2.10 times greater than the average cost of a US accident. In terms of the total dollar cost of VN accidents, the Table I data show that it was 5.93 times greater than the cost of all accidents occurring elsewhere.

To facilitate the comparison of these fiscal year 1968 data with accident incidence data presented for the other years of the study, the data sets in Figure 2 have been normalized relative to the total number of flying hours flown by each type of aircraft in both locales and plotted in Figure 4A as the average number of accidents occurring every 100,000 hours. The same normalization with total landings as reference was accomplished for Figure 4B which shows the accident rate for every 100,000 landings. The extent to which the VN accident rate exceeded that occurring elsewhere is shown in Figures 5A and 5B, which plot the VN/US accident ratio for the different types of aircraft with equal flying hours and equal landings, respectively, as weighting factors. When an equal number of flying hours was used as reference, the incidence of accidents in VN was 1.42 times greater than the incidence in US for FW aircraft, 2.70 times greater for RW aircraft, and 2.44 times greater for their combined total. For the equal landings data of Figure 5B, the VN/US accident ratio climbed to 4.40 to 1 for FW aircraft, 4.13 to 1 for RW aircraft, and 3.91 to 1 for their total. Thus, without exception, these data show that accident incidence was greater in VN. These fiscal year 1968 findings are in direct support of the fiscal year 1967 data with regard to establishing the significantly greater accident hazard and accident cost associated with the stresses of a combat-oriented environment.

To show the relationship between accident incidence in RW aircraft and that in FW aircraft, ratio of the RW to FW accident rate data presented in Figure 5 is plotted for the two locations in Figure 6. These data are also listed in Table IV. In Figure 6A, the RW/FW accident ratio of 0.92 to 1 for accidents occurring in the US indicates that the hazard here was about equal for both aircraft types. In VN, however, the incidence of accidents in RW aircraft was about 1.75 times greater than that in FW aircraft with equal flying hours as reference. However, when equal landings were used as reference, as is done in Figure 6B, these data showed a RW/FW accident ratio much less than unity, indicating a higher incidence for FW accidents. It may also be observed from the data of Figure 6B that the RW/FW accident ratio was about the same for accidents occurring in VN as for those occurring elsewhere.

## PILOT-ERROR ACCIDENTS

In this section, incidence and cost data are presented for all accidents that were classified by USABAAR as involving one or more pilot-error causal factors. It should be observed that this classification does not imply that pilot error was the only, or even the primary, accident causal factor. That is, this grouping includes all accidents involving one or more pilot errors even though, for example, material failure,

TABLE V FISCAL YEAR 1968 DATA				
PILOT-ERROR ACCIDENTS ONLY		ALL AIRCRAFT		
ACCIDENT INDEX	U.S. ACCIDENTS	VIET NAM ACCIDENTS	ALL ACCIDENTS	VN to US RATIO
Major Accidents	178	489	667	2.75
Minor Accidents	14	21	35	1.50
Total Accidents	192	510	702	2.66
Total Dollar Cost	11,057,468	60,465,236	71,522,704	5.47
Average Dollar Cost per Accident	57,591	118,559	101,884	2.06
Total Fatalities	28	204	232	7.29
Average Fatalities per Accident	0.15	0.40	0.33	2.67
Fatal Accidents - Number	14	65	79	4.64
Fatal Accidents - Percent	7.29	12.75	11.25	1.75
Average Fatalities per Fatal Accident	2.00	3.14	2.94	1.57
Total Injuries (Nonfatal)	86	579	665	6.73
Average Injuries per Accident (Nonfatal)	0.45	1.14	0.95	2.53

TABLE VI FISCAL YEAR 1968 DATA				
PILOT-ERROR ACCIDENTS ONLY		FIXED WING AIRCRAFT		
ACCIDENT INDEX	U.S. ACCIDENTS	VIET NAM ACCIDENTS	ALL ACCIDENTS	VN to US RATIO
Major Accidents	41	64	105	1.56
Minor Accidents	3	3	6	1.00
Total Accidents	44	67	111	1.52
Total Dollar Cost	3,147,652	5,813,226	8,960,878	1.85
Average Dollar Cost per Accident	71,538	86,765	80,729	1.21
Total Fatalities	11	19	30	1.73
Average Fatalities per Accident	0.25	0.28	0.27	1.12
Fatal Accidents - Number	6	8	14	1.33
Fatal Accidents - Percent	13.64	11.94	12.61	0.88
Average Fatalities per Fatal Accident	1.83	2.38	2.14	1.30
Total Injuries (Nonfatal)	15	30	45	2.00
Average Injuries per Accident (Nonfatal)	0.34	0.45	0.41	1.32

TABLE VII FISCAL YEAR 1968 DATA				
PILOT-ERROR ACCIDENTS ONLY		ROTARY WING AIRCRAFT		
ACCIDENT INDEX	U.S. ACCIDENTS	VIET NAM ACCIDENTS	ALL ACCIDENTS	VN to US RATIO
Major Accidents	137	425	562	3.10
Minor Accidents	11	18	29	1.64
Total Accidents	148	443	591	2.99
Total Dollar Cost	7,909,816	54,652,010	62,561,826	6.91
Average Dollar Cost per Accident	53,445	123,368	105,858	2.31
Total Fatalities	17	185	202	10.88
Average Fatalities per Accident	0.11	0.42	0.34	3.82
Fatal Accidents - Number	8	57	65	7.13
Fatal Accidents - Percent	5.41	12.87	11.00	2.38
Average Fatalities per Fatal Accident	2.13	3.25	3.11	1.53
Total Injuries (Nonfatal)	71	549	620	7.73
Average Injuries per Accident(Nonfatal)	0.48	1.24	1.05	2.58

TABLE VIII FISCAL YEAR 1968 DATA			
PILOT-ERROR ACCIDENTS ONLY		RATIO OF RW TO FW DATA	
ACCIDENT INDEX	U.S. ACCIDENTS	VIET NAM ACCIDENTS	ALL ACCIDENTS
Major Accidents	3.34	6.64	5.35
Minor Accidents	3.67	6.00	4.83
Total Accidents	3.36	6.61	5.32
Total Dollar Cost	2.51	9.40	6.98
Average Dollar Cost per Accident	0.75	1.42	1.31
Total Fatalities	1.55	9.74	6.73
Average Fatalities per Accident	0.44	1.50	1.26
Fatal Accidents - Number	1.33	7.13	4.64
Fatal Accidents - Percent	0.40	1.08	0.87
Average Fatalities per Fatal Accident	1.16	1.37	1.45
Total Injuries (Nonfatal)	4.73	18.30	13.78
Average Injuries per Accident (Nonfatal)	1.41	2.76	2.56

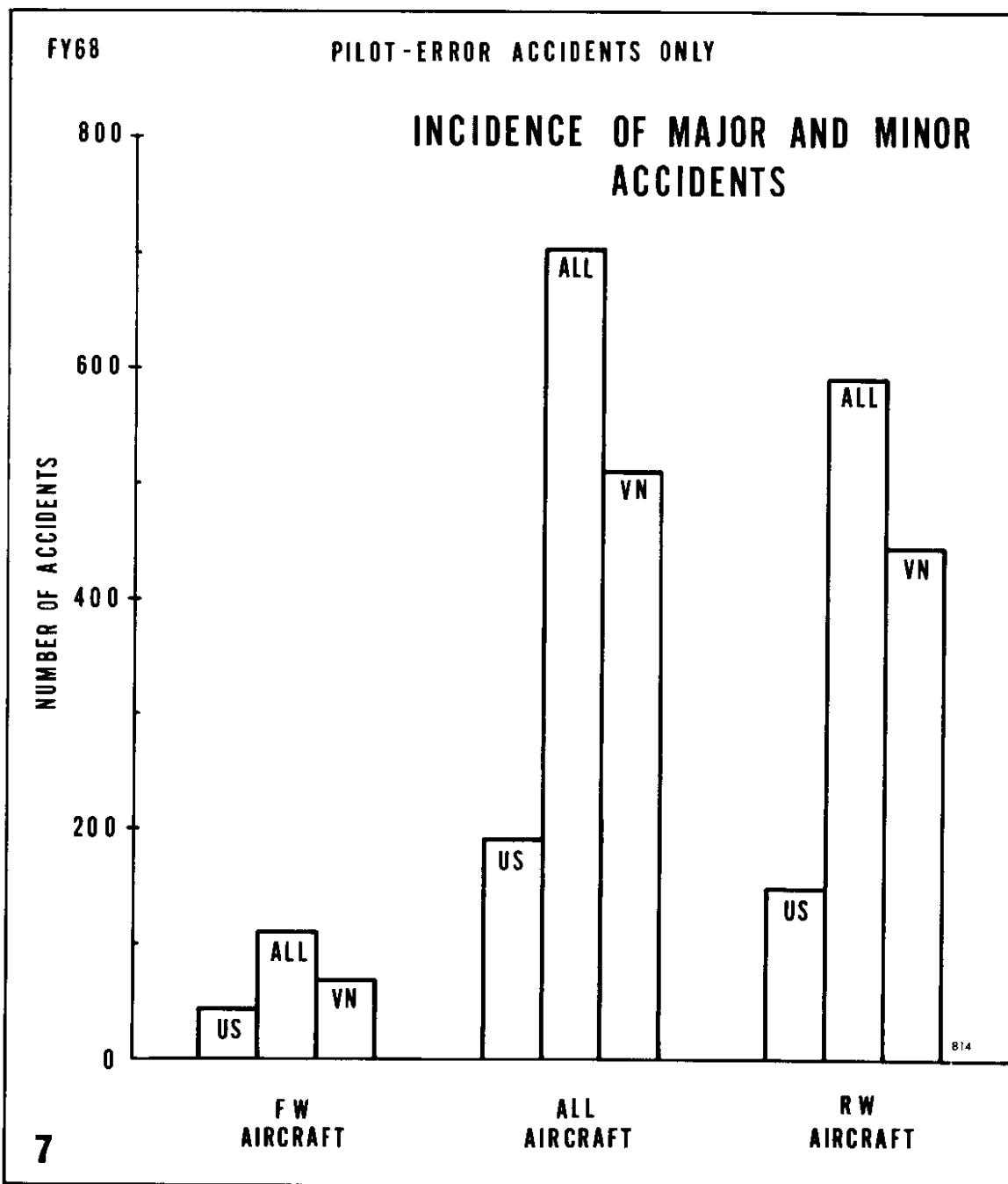


Figure 7

Pilot-Error Accident Types: Total number of major and minor accidents that were classified by USABAAR as involving one or more pilot-error factors. As with the Figure 2 "All Accident Type" incidence data, the number of pilot-error accidents occurring in RW aircraft operating out of VN considerably exceeded those occurring elsewhere. However, for FW aircraft, the number of pilot-error accidents that occurred in VN only slightly exceeded those that occurred in US. Considering all aircraft, the VN incidence was 2.66 times greater than the US incidence.



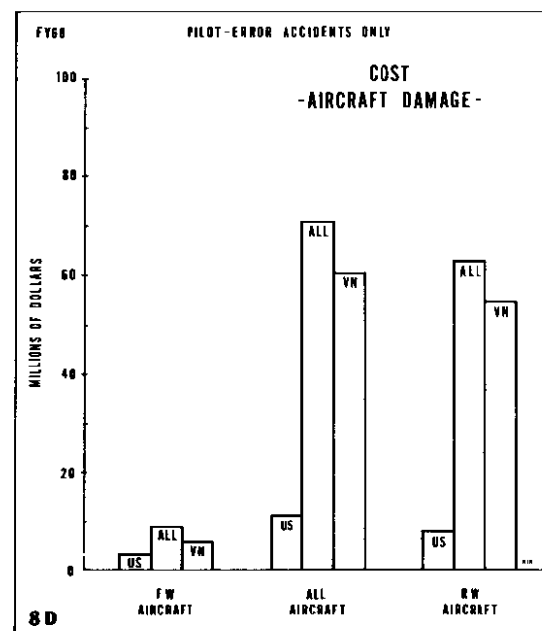
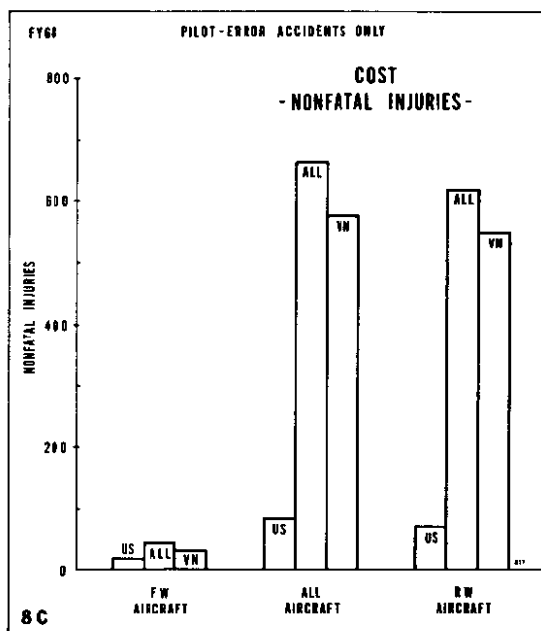
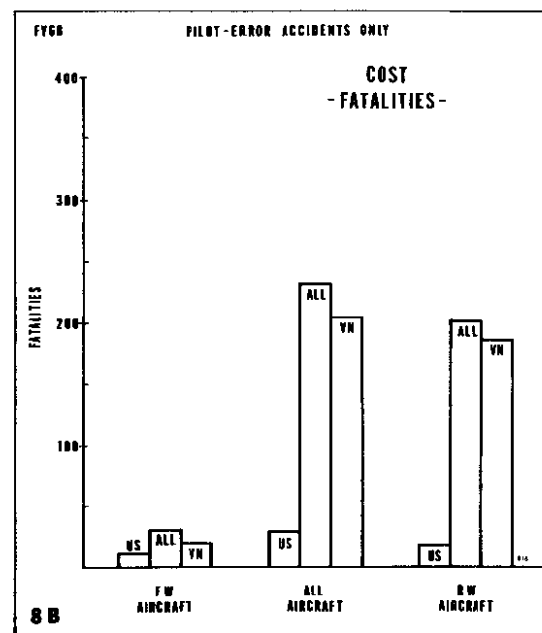
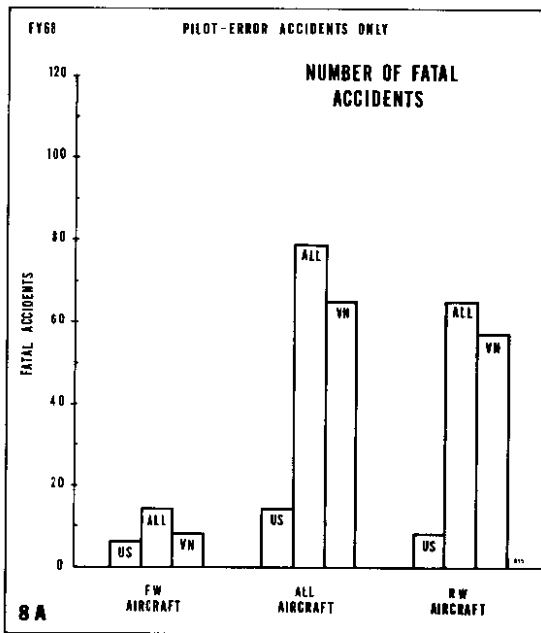


Figure 8

Pilot-Error Accident Types: Total number of fatal accidents (A), total number of fatalities (B), total number of nonfatal injuries (C), and total dollar cost of resulting aircraft damage (D) for both aircraft types and for both locations. The VN costs, in all cases, were greater.

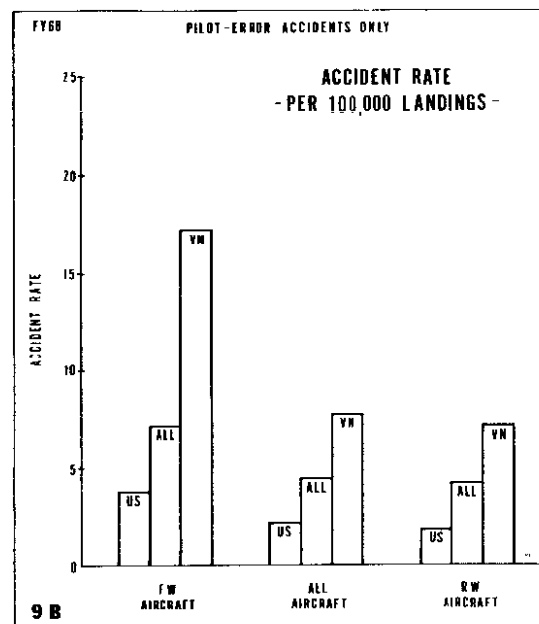
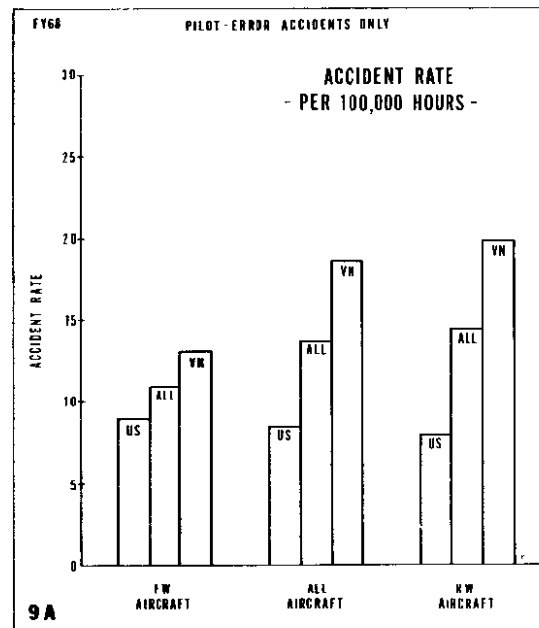


Figure 9

Pilot-Error Accident Types: Normalized incidence data showing average number of pilot-error accidents per 100,000 flying hours (A) and average number of pilot-error accidents per 100,000 landings (B). These rate data are intended only as a fiscal year 1968 baseline reference for comparison with similar data calculated for other fiscal years of the longitudinal study. For FW aircraft, the over-all rates were 10.99 and 7.13 accidents per 100,000 hours and per 100,000 landings, respectively. For RW aircraft, the over-all rates were 14.36 and 4.18 accidents per 100,000 hours and per 100,000 landings, respectively.

maintenance shortcomings, or poor facilities may also have contributed to the cause of the accident. A further point, by definition, is that these pilot-error accidents are a subgroup of the all-accident statistics discussed in the previous section.

Incidence and cost data for these fiscal year 1968 pilot-error accidents are presented in Tables V through VIII, with the Table V data pertaining to accidents in all types of aircraft, the Table VI data to only FW accident, the Table VII data to only RW accidents, and the Table VIII data describing the ratio of the RW to FW data presented in Tables VII and VI, respectively. Selected incidence and cost data are depicted in Figures 7 and 8. Normalized accident rate data, based on the total hours and total landings data of Figure 1 are plotted in Figure 9. These rate data, as with the rate data of Figure 4, are intended primarily as a baseline reference for comparison with similar data presented for other fiscal years of the study.

The incidence data of Figure 7 show that there were a total of 702 major and minor accidents involving pilot error; of this total, 79 were fatal accidents. The over-all cost was 232 fatalities, 665 nonfatal injuries, and \$71,522,704 aircraft damage. The FW contribution to these totals was 111 accidents (14 of which were fatal), resulting in 30 fatalities, 45 nonfatal injuries, and \$8,960,878 aircraft damage. For RW aircraft, there were 591 accidents (65 of which were fatal), resulting in 202 fatalities, 620 non-fatal injuries, and \$62,561,826 aircraft damage. The VN/US accident incidence ratio was 1.52 to 1 for FW aircraft and 2.99 to 1 for RW aircraft.

As with the all-accident data, the cost of RW pilot-error accidents that occurred in VN was also considerable. As shown in Table VII and Figure 8, there were 7.13 times more fatal RW accidents in VN as there were elsewhere; there were also 10.88 times more fatalities and 7.73 times more nonfatal injuries. Furthermore, the average cost in dollars damage resulting from a VN accident was 2.31 times greater than the average cost of a US accident. In terms of total cost in dollars damage, the cost in VN was 6.91 times more than the cost in US. It should be observed in Figure 8, however, that the corresponding VN/US cost ratios for FW pilot-error accidents were lower.

The pilot-error accident rate data presented in Figure 9 also establish the higher cost of VN operations. For FW aircraft the over-all accident rates were 10.99 and 7.13 accidents per 100,000 hours and per 100,000 landings, respectively. The VN rate was 1.48 times the US rate based on hours and 4.60 times the US rate based on landings. For RW aircraft the over-all pilot-error accident rates were 14.36 and 4.18 accidents per 100,000 hours and per 100,000 landings, respectively. The VN rate was 2.51 times the US rate based on hours and 3.84 times the US rate based on landings.

## ORIENTATION-ERROR ACCIDENTS ONLY

This section summarizes the incidence and cost of all orientation-error type accidents detected in our review of the USABAAR accident files. As detailed with selected qualifications in the procedure section of this report, this listing includes all accidents arising from an incorrect control or power action taken by a pilot due to his incorrect perception of the true motion or attitude of his aircraft. The reader should recognize

that the orientation-error accidents discussed herein are a subgroup of the pilot-error accident statistics presented in the previous section.

The main elements of the orientation-error statistics are summarized in Tables IX through XII, with the Table IX data pertaining to accidents in all types of aircraft, the Table X data to only FW accidents, the Table XI data to only RW accidents, and the Table XII data describing the ratio of the RW to FW data presented in Tables XI and X, respectively. The pertinent incidence and cost data are outlined in Figures 10 and 11. Normalized accident rate data for these accidents are presented in Figure 12 for comparison of incidence in other fiscal years of the longitudinal study.

These data show that there were a total of 75 major and minor orientation-error accidents (26 of which were fatal), resulting in 91 fatalities, 75 nonfatal injuries, and an aircraft damage cost of \$12,381,805. The FW contribution was relatively small with no minor accidents and 9 major accidents occurring; the over-all cost here was 5 fatal accidents, 11 fatalities, 5 nonfatal injuries, and a total dollar damage of \$3,304,740. It is obvious that with such a low incidence ( $n$ ) for fiscal year 1968 FW orientation-error accidents, conclusions to be drawn as to RW/FW or US/VN accident incidence and cost must await the acquisition of further FW data in this longitudinal study. For RW aircraft, there were a total of 66 major and minor orientation-error accidents (21 of which were fatal), resulting in 80 fatalities, 70 nonfatal injuries, and a total of \$9,077,065 aircraft damage. Thus the majority of the orientation-error accidents involving Regular Army aircraft occurred in RW aircraft in that fiscal year. As indicated by the RW data, the incidence and cost of accidents occurring in VN were both considerably greater than for accidents occurring elsewhere. This is particularly noticeable in the 4.25 to 1 VN/US fatal accident ratio, the 9.00 to 1 VN/US total fatality ratio, the 6.78 to 1 VN/US total injury ratio, and the 8.07 to 1 VN/US total dollar cost ratio.

The rate data in Figure 12 indicate that for FW aircraft, the over-all accident rates were 0.89 and 0.58 accidents per 100,000 hours and per 100,000 landings, respectively. For RW aircraft, the over-all rates were 1.60 and 0.47 accidents per 100,000 hours and per 100,000 landings, respectively.

## COMPARATIVE INCIDENCE AND COST OF ORIENTATION-ERROR ACCIDENTS

The arrangement of the data presented in the previous sections was selected to differentiate the actual incidence and cost of all accidents, pilot-error accidents, and orientation-error accidents. In this section, selected incidence and cost data are expressed in percentage figures, with the objective of gaining some insight into the relative contribution of orientation-error accidents to the over-all accident problem.

In Figure 13 the percent incidence of fatal accidents is described for all accident types, pilot-error accident types, and orientation-error accident types. The Figure 13A data show that for FW aircraft, 14.00 percent of all FW accidents, regardless of accident cause or type, were fatal, with the incidence in VN being about 1.11 times greater than that in the US. The RW data show that 13.12 percent of all RW accidents were fatal,

TABLE IX FISCAL YEAR 1968 DATA ORIENTATION-ERROR ACCIDENTS ONLY ALL AIRCRAFT				
ACCIDENT INDEX	U.S. ACCIDENTS	VIET NAM ACCIDENTS	ALL ACCIDENTS	VN to US RATIO
Major Accidents	12	63	75	5.25
Minor Accidents	0	0	0	---
Total Accidents	12	63	75	5.25
Total Dollar Cost	1,136,477	11,245,328	12,381,805	9.89
Average Dollar Cost per Accident	94,706	178,497	165,091	1.88
Total Fatalities	13	78	91	6.00
Average Fatalities per Accident	1.08	1.24	1.21	1.15
Fatal Accidents - Number	5	21	26	4.20
Fatal Accidents - Percent	41.67	33.33	34.67	0.79
Average Fatalities per Fatal Accident	2.60	3.71	3.50	1.43
Total Injuries (Nonfatal)	9	66	75	7.33
Average Injuries per Accident (Nonfatal)	0.75	1.05	1.00	1.40

TABLE X FISCAL YEAR 1968 DATA ORIENTATION-ERROR ACCIDENTS ONLY FIXED WING AIRCRAFT				
ACCIDENT INDEX	U.S. ACCIDENTS	VIET NAM ACCIDENTS	ALL ACCIDENTS	VN to US RATIO
Major Accidents	2	7	9	3.50
Minor Accidents	0	0	0	---
Total Accidents	2	7	9	3.50
Total Dollar Cost	135,572	3,169,168	3,304,740	23.38
Average Dollar Cost per Accident	67,786	452,738	367,193	6.68
Total Fatalities	5	6	11	1.20
Average Fatalities per Accident	2.50	0.86	1.22	0.34
Fatal Accidents - Number	1	4	5	4.00
Fatal Accidents - Percent	50.00	57.14	55.56	1.14
Average Fatalities per Fatal Accident	5.00	1.50	2.20	0.30
Total Injuries (Nonfatal)	0	5	5	---
Average Injuries per Accident (Nonfatal)	---	0.71	0.56	---

TABLE XI FISCAL YEAR 1968 DATA ORIENTATION-ERROR ACCIDENTS ONLY				
ROTARY WING AIRCRAFT				
ACCIDENT INDEX	U.S. ACCIDENTS	VIET NAM ACCIDENTS	ALL ACCIDENTS	VN to US RATIO
Major Accidents	10	56	66	5.60
Minor Accidents	0	0	0	---
Total Accidents	10	56	66	5.60
Total Dollar Cost	1,000,905	8,076,160	9,077,065	8.07
Average Dollar Cost per Accident	100,090	144,217	137,531	1.44
Total Fatalities	8	72	80	9.00
Average Fatalities per Accident	0.80	1.29	1.21	1.61
Fatal Accidents - Number	4	17	21	4.25
Fatal Accidents - Percent	40.00	30.36	31.82	0.76
Average Fatalities per Fatal Accident	2.00	4.24	3.81	2.12
Total Injuries (Nonfatal)	9	61	70	6.78
Average Injuries per Accident (Nonfatal)	0.90	1.09	1.06	1.21

TABLE XII FISCAL YEAR 1968 DATA ORIENTATION-ERROR ACCIDENTS ONLY			
RATIO OF RW TO FW DATA			
ACCIDENT INDEX	U.S. ACCIDENTS	VIET NAM ACCIDENTS	ALL ACCIDENTS
Major Accidents	5.00	8.00	7.33
Minor Accidents	---	---	---
Total Accidents	5.00	8.00	7.33
Total Dollar Cost	7.38	2.55	2.75
Average Dollar Cost per Accident	1.48	0.32	0.37
Total Fatalities	1.60	12.00	7.27
Average Fatalities per Accident	0.32	1.50	0.99
Fatal Accidents - Number	4.00	4.25	4.20
Fatal Accidents - Percent	0.80	0.53	0.57
Average Fatalities per Fatal Accident	0.40	2.83	1.73
Total Injuries (Nonfatal)	---	12.20	14.00
Average Injuries per Accident (Nonfatal)	---	1.54	1.89

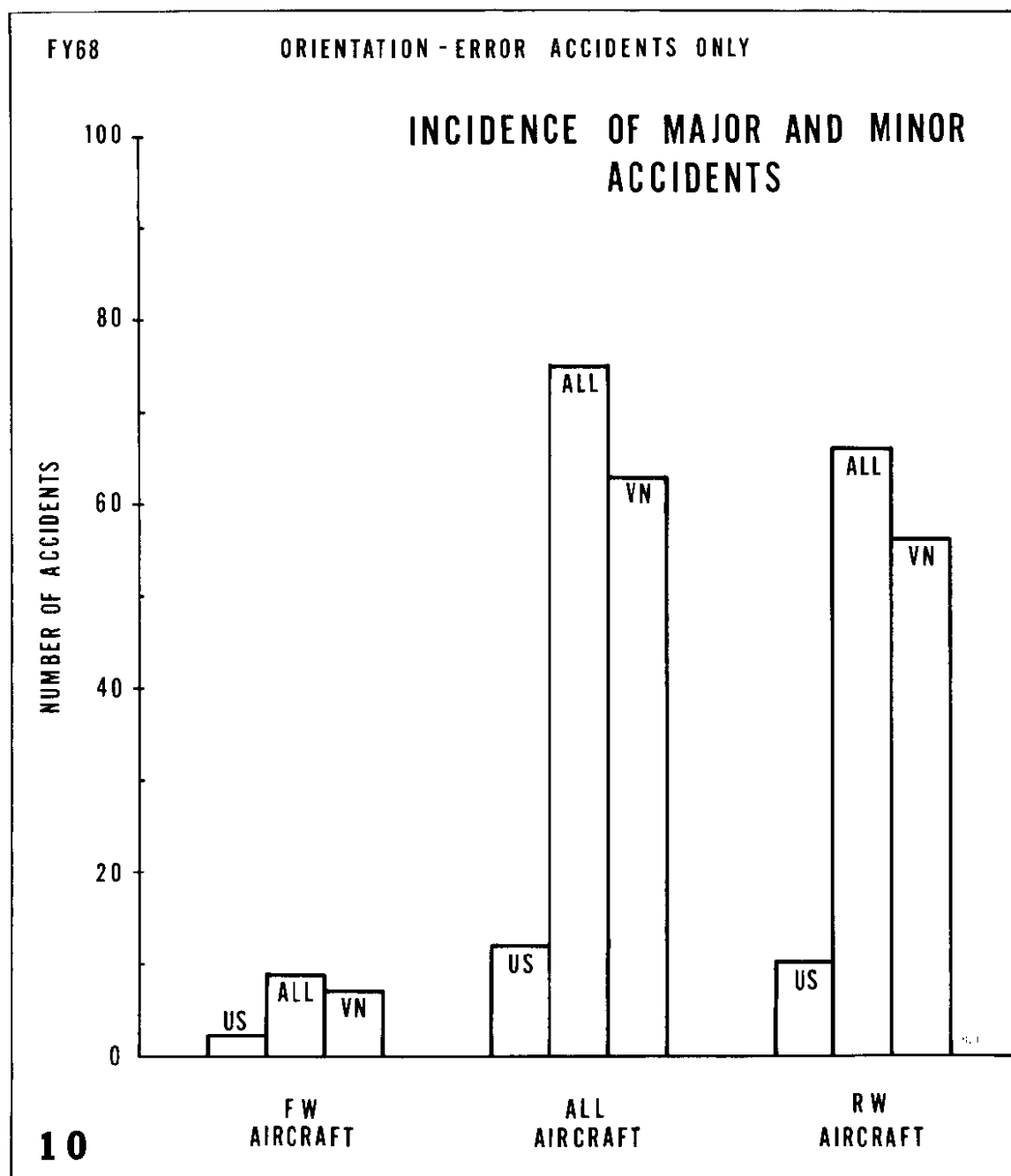


Figure 10

Orientation-Error Accident Types: Total number of major and minor orientation-error accidents located in the search of the USABAAR master accident files for fiscal year 1968. Considering all aircraft, the incidence of orientation-error accidents in VN was 5.25 times the incidence of similar accidents elsewhere.

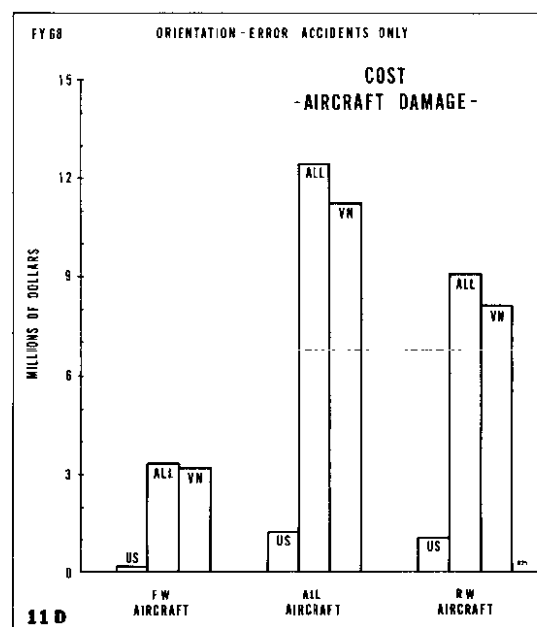
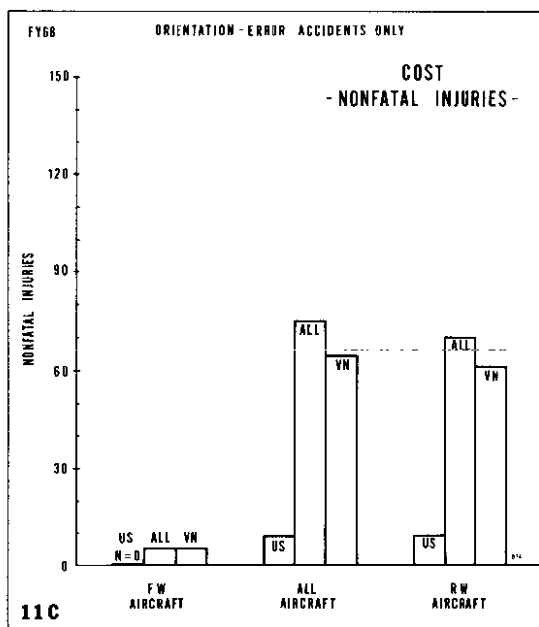
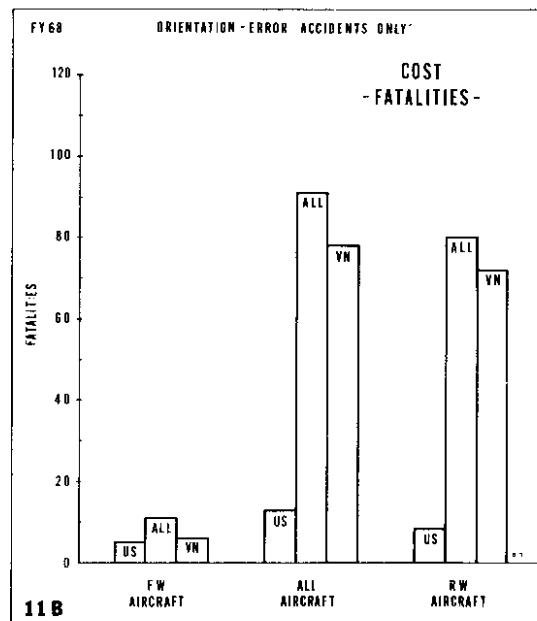
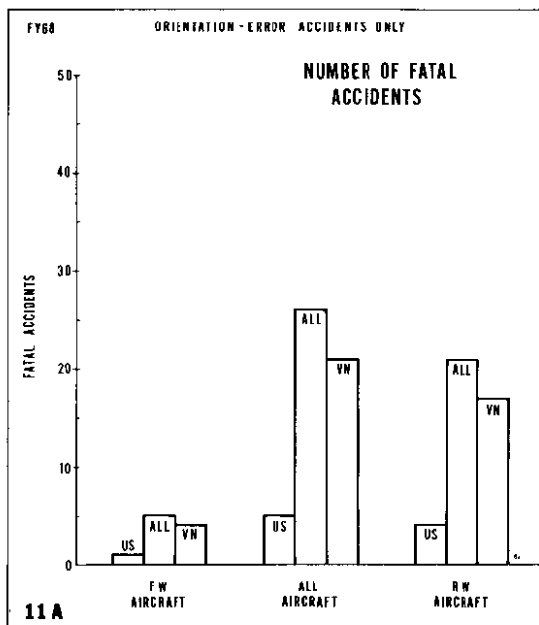


Figure 11

Orientation-Error Accident Types: Total number of fatal accidents (A), total number of fatalities (B), total number of nonfatal injuries (C), and total dollar cost of resulting aircraft damage (D) for both aircraft types and for both locations.



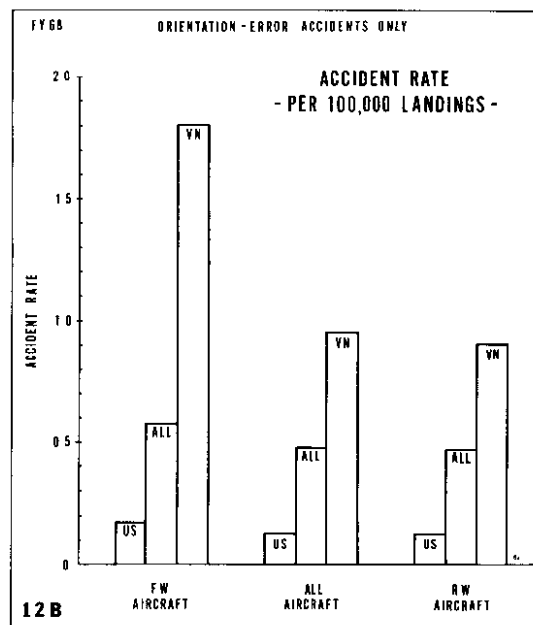
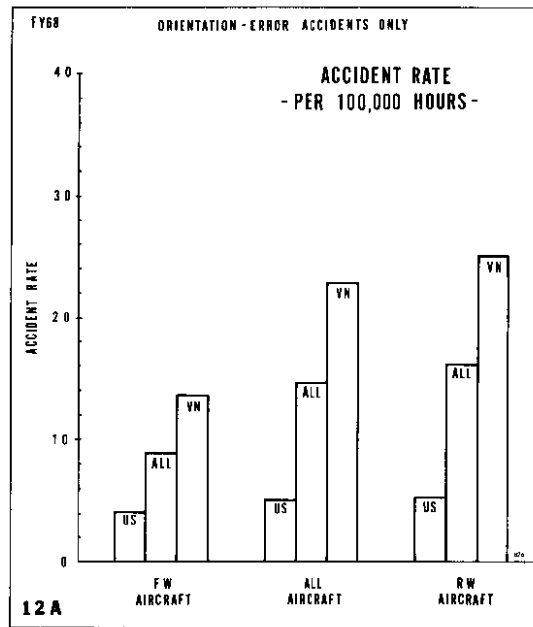


Figure 12

Orientation-Error Accident Types: Normalized incidence data showing overage number of orientation-error accidents per 100,000 flying hours (A), and per 100,000 landings (B). These rate data are intended only as a fiscal year 1968 baseline reference for comparison with similar data calculated for other fiscal years of the longitudinal study. For all aircraft types, the over-all rates were 1.46 and 0.48 orientation-error accidents per 100,000 hours and per 100,000 landings, respectively.

with the VN incidence 1.14 times greater than the US incidence. In effect, considering all accidents, little difference existed in the percent incidence of fatal accidents relative to location for either type of aircraft. Considering both aircraft types together, the totalized data of Figure 13A show that 13.24 percent of all accidents were fatal.

When one evaluates only those accidents of the above group that involved pilot error, the relative incidence of fatal accidents is slightly less, as indicated in Figure 13B. Here, the fatal accident incidence was 12.61 percent for FW aircraft, 11.00 percent for RW aircraft, and 11.25 percent for the combined sum of FW and RW pilot-error accidents. The VN/US fatal accident percent incidence ratio for RW aircraft was 2.38 to 1 as compared to only a 0.88 to 1 ratio for FW aircraft. A comparison of Figure 13A and 13B would indicate that during fiscal year 1968, the probability of a fatal accident occurring when pilot error was involved was slightly less than the probability of a fatal accident occurring when pilot error was not involved.

For orientation-error accidents, however, the probability of a fatal accident was much higher, as shown in Figure 13C. Again, the reader is cautioned to remember the low incidence of FW accidents for this period. The total number of FW accidents,  $n=9$ , of which five were fatal, accounts for the 56 percent fatal accident incidence data of this figure. Thus for fiscal year 1968, the relative incidence and cost of orientation-error accidents derived predominantly from RW accidents. In the remaining orientation-error figures then, the "All Aircraft" data will, in essence, be identical to the "RW Aircraft" data. The percent incidence of fatal accidents when orientation error was involved was 33.33 percent in VN and 41.67 percent in US.

Similar comparisons for the three classes of accidents are made in Figure 14 for the average number of fatalities per fatal accident. Again, for all aircraft, the cost of pilot-error accident types was slightly less than the cost of all accident types. However, for orientation-error accidents the average number of fatalities per fatal accident was slightly greater than that of the all accident types. The same format is used in Figure 15 which depicts the average number of nonfatal injuries that occurred per accident. The injury cost for all aircraft types was approximately the same for all three accident classifications. However, in terms of the average dollar cost data presented in Figure 16, orientation-error accidents resulted in the greatest loss.

Figures 17 through 20 illustrate the relative contribution of orientation-error accidents in all aircraft types to selected incidence and cost data as a given percentage of corresponding statistics for both "all accident types" and "pilot-error accident types." In Figure 17, orientation-error accidents can be seen to represent 7.20 percent of all accidents that occurred during fiscal year 1968 and 10.68 percent of all pilot-error accidents. When one considers the number of fatal accidents that occurred in the two accident groups, as is done in Figure 18, orientation-error fatal accidents represent 18.84 percent of all fatal accidents and 32.91 percent of all fatal pilot-error accidents. In terms of fatalities, orientation-error accidents resulted in 21.21 percent of the total number and in 39.22 percent of those occurring in pilot-error accidents, as indicated in Figure 19. Lastly, orientation-error accidents accounted for 10.65 percent of the

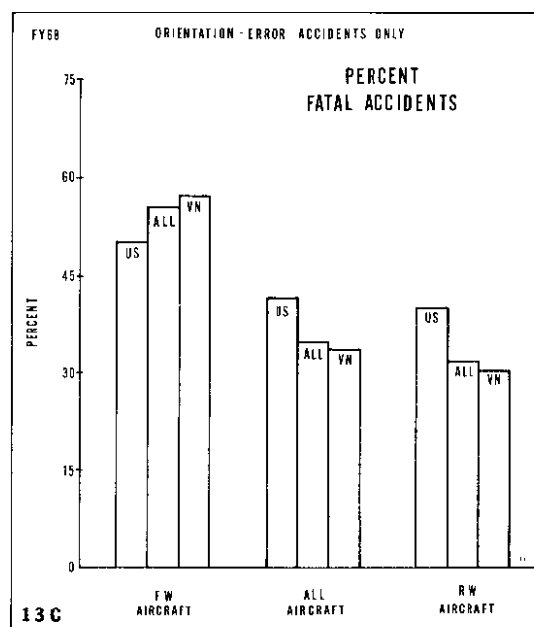
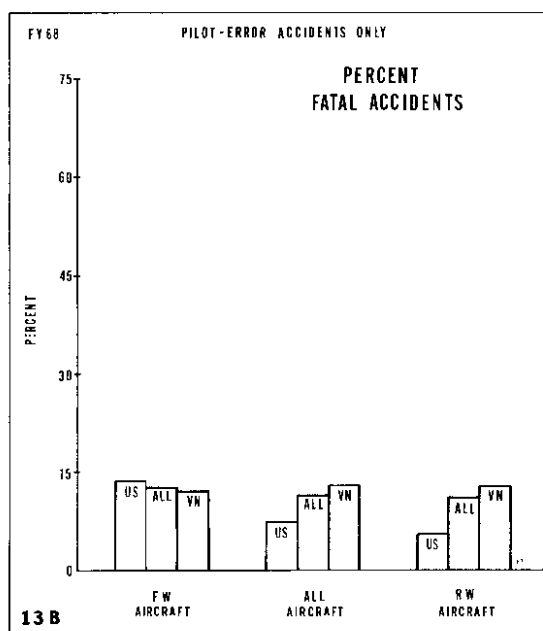
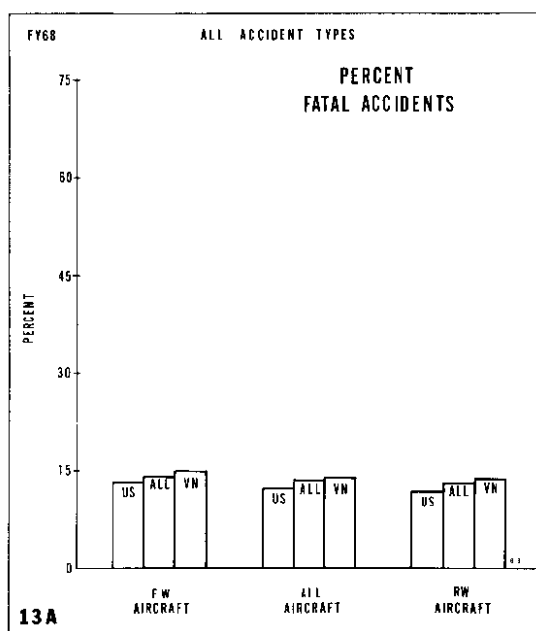


Figure 13

Comparative incidence of fatal accidents expressed as the percent of the total number of accidents within the "All Accident Type" (A), "Pilot-Error Accident Type" (B), and "Orientation-Error Accident Type" (C) classifications that resulted in one or more fatalities. Note that orientation-error accidents had a significantly higher percentage of fatal accidents.

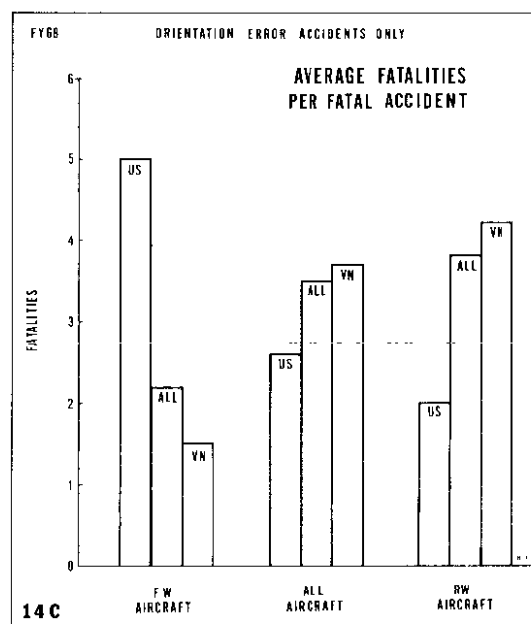
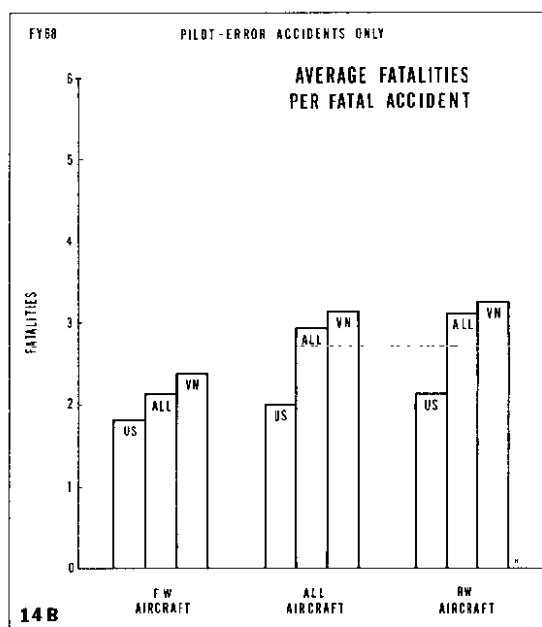
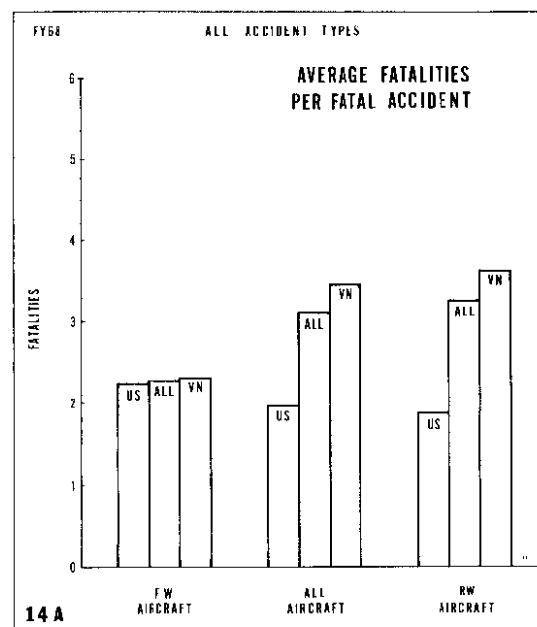


Figure 14

Average number of fatalities per fatal accident occurring within the "All Accident Type" (A), "Pilot-Error Accident Type" (B), and "Orientation-Error Accident Type" (C) classifications.

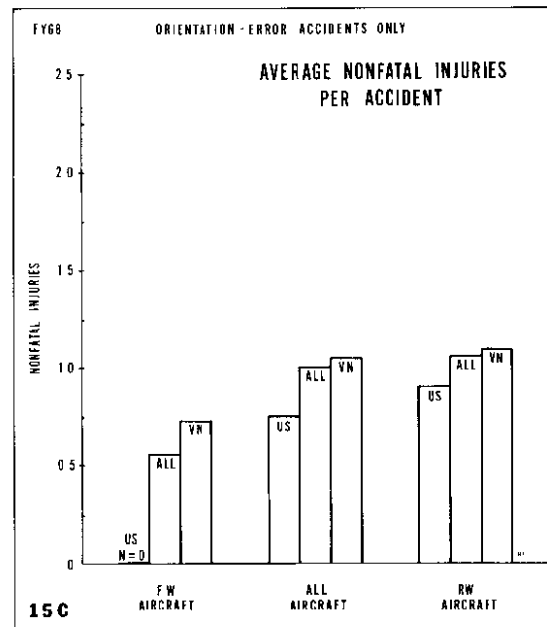
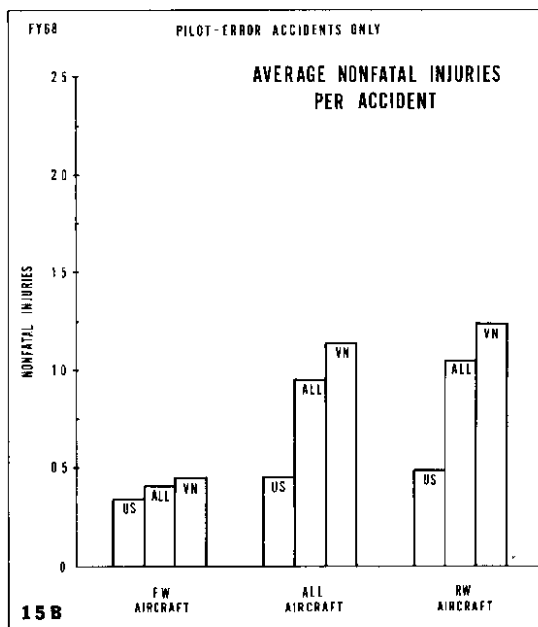
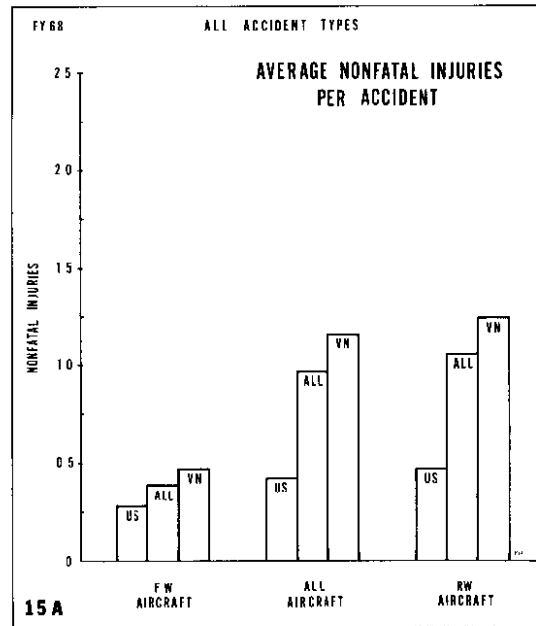


Figure 15

Average number of nonfatal injuries per accident occurring within the "All Accident Type" (A), "Pilot-Error Accident Type" (B), and "Orientation-Error Accident Type" (C) classifications.

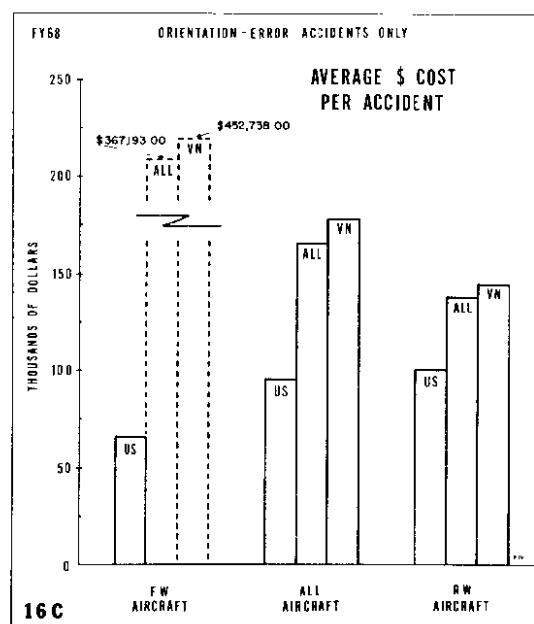
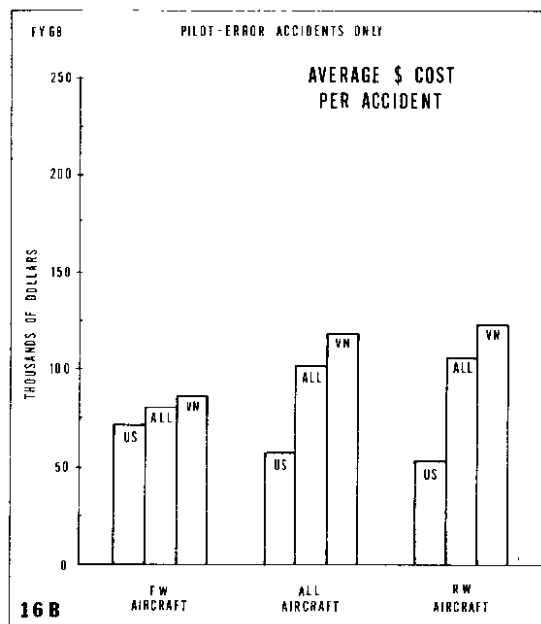
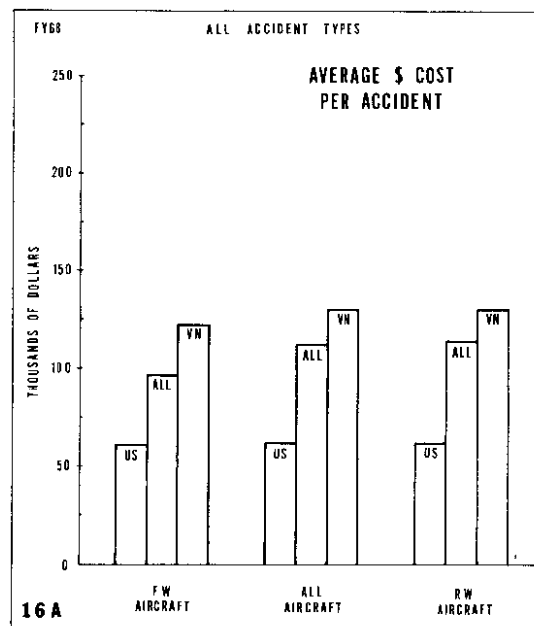


Figure 16

Average aircraft dollar damage per accident occurring within the "All Accident Type" (A), "Pilot-Error Accident Type" (B), and "Orientation-Error Accident Type" (C) classifications.

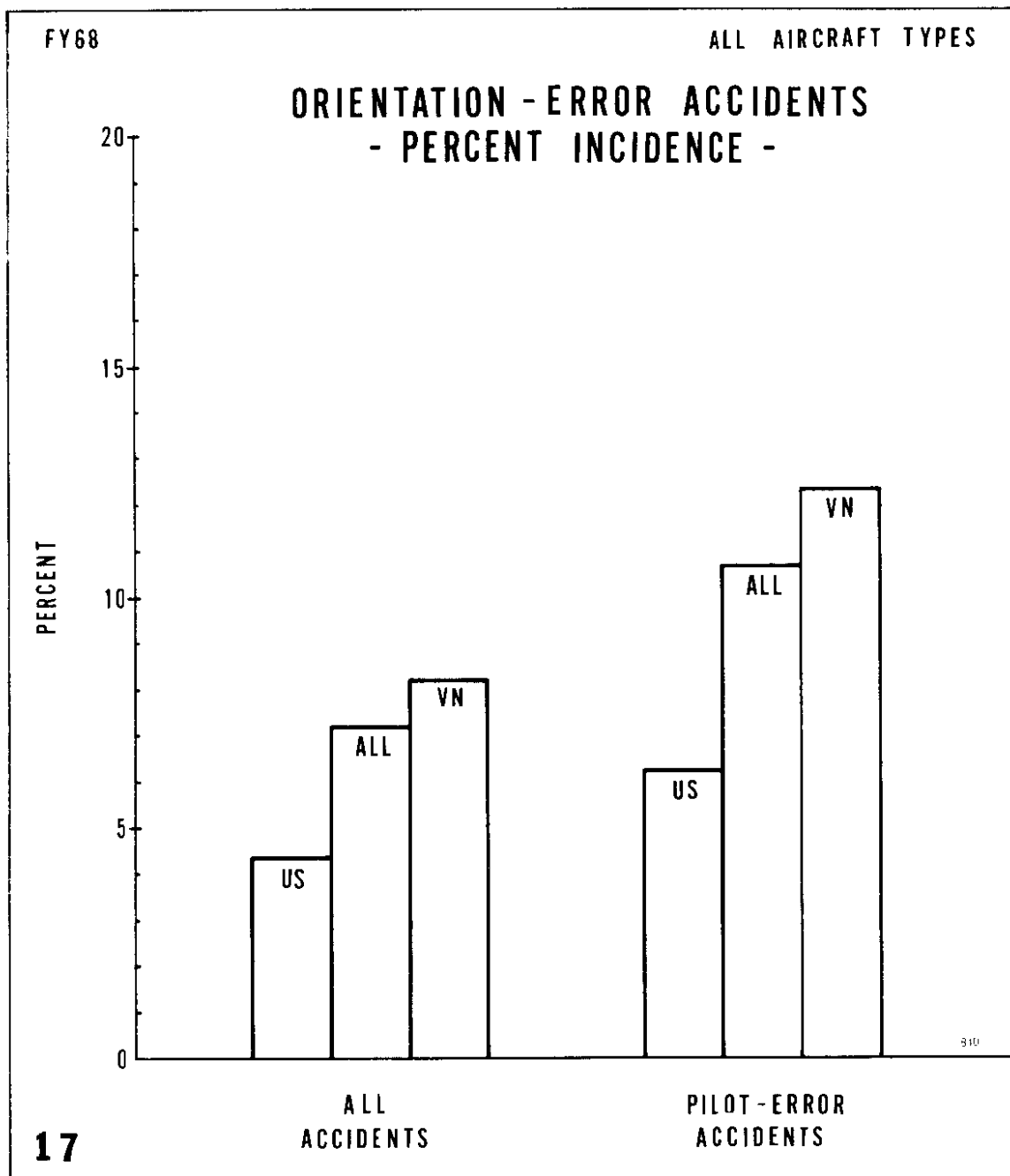


Figure 17

Percent contribution of all orientation-error accidents to the total number of accidents occurring within the "All Accident Type" and the "Pilot-Error Accident Type" classifications. Considering all types of aircraft, orientation-error accidents accounted for 7.20 percent of all accidents and 10.68 percent of all pilot-error accidents.

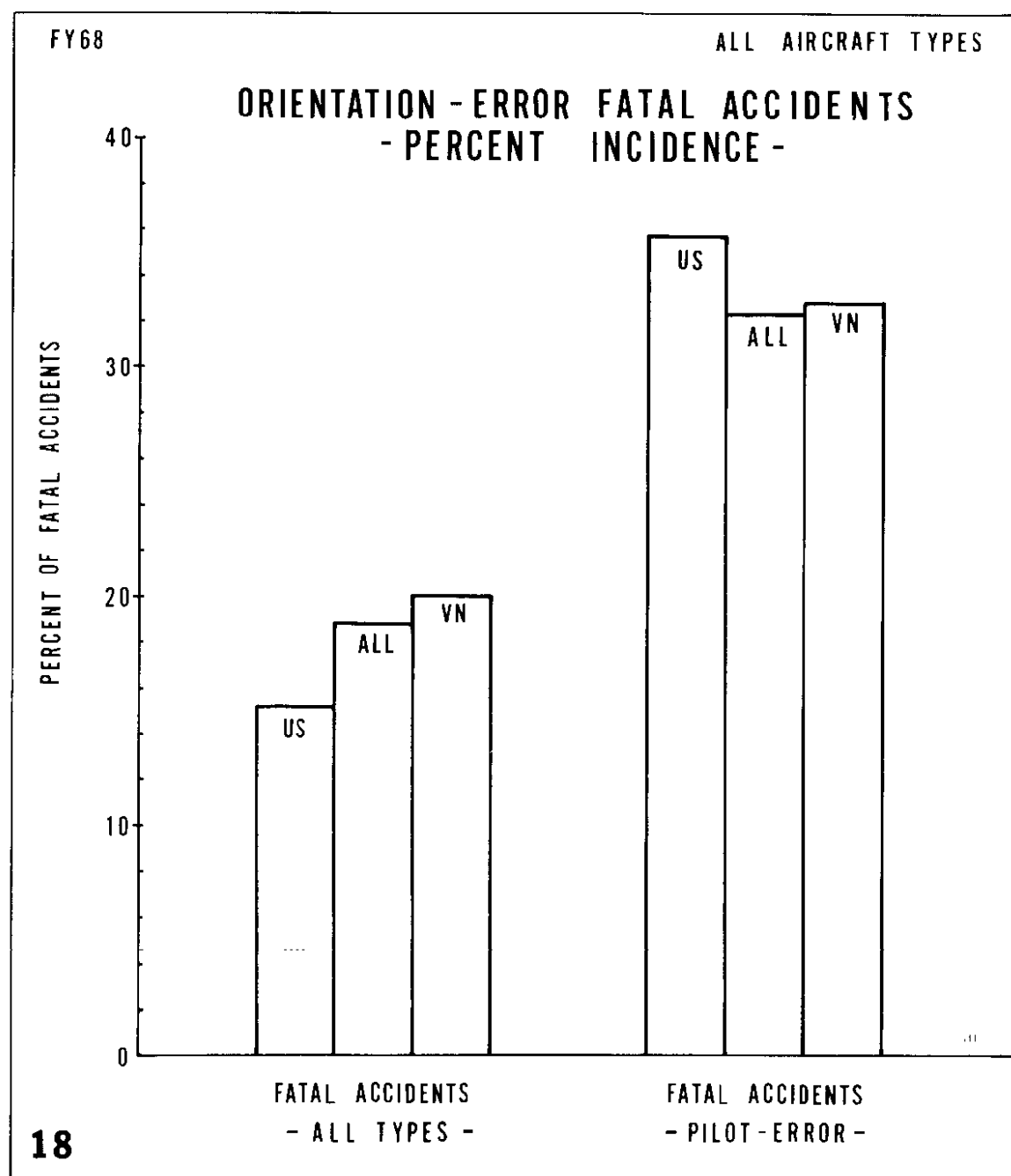


Figure 18

Percent contribution of all fatal orientation-error accidents to the total number of fatal accidents occurring within the "All Accident Type" and the "Pilot-Error Accident Type" classifications. Orientation-error accidents accounted for 18.84 percent of all fatal accidents and 32.91 percent of all fatal pilot-error accidents.



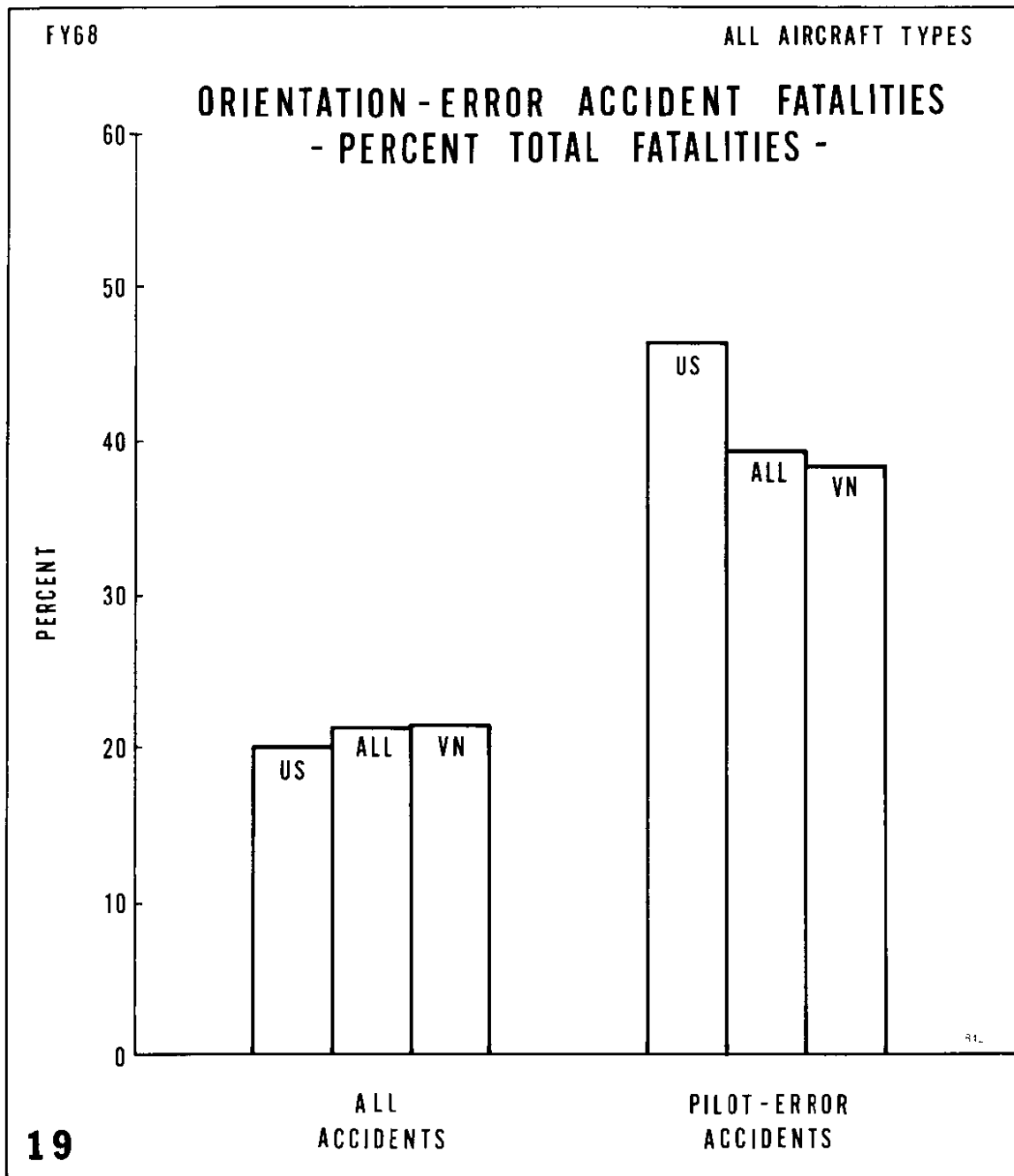


Figure 19

Percent contribution of all orientation-error accident fatalities to the total number of fatalities occurring within the "All Accident Type" and the "Pilot-Error Accident Type" classifications. Orientation-error accidents accounted for 21.21 percent of the total number of fatalities and 39.22 percent of the fatalities due to pilot-error accidents.

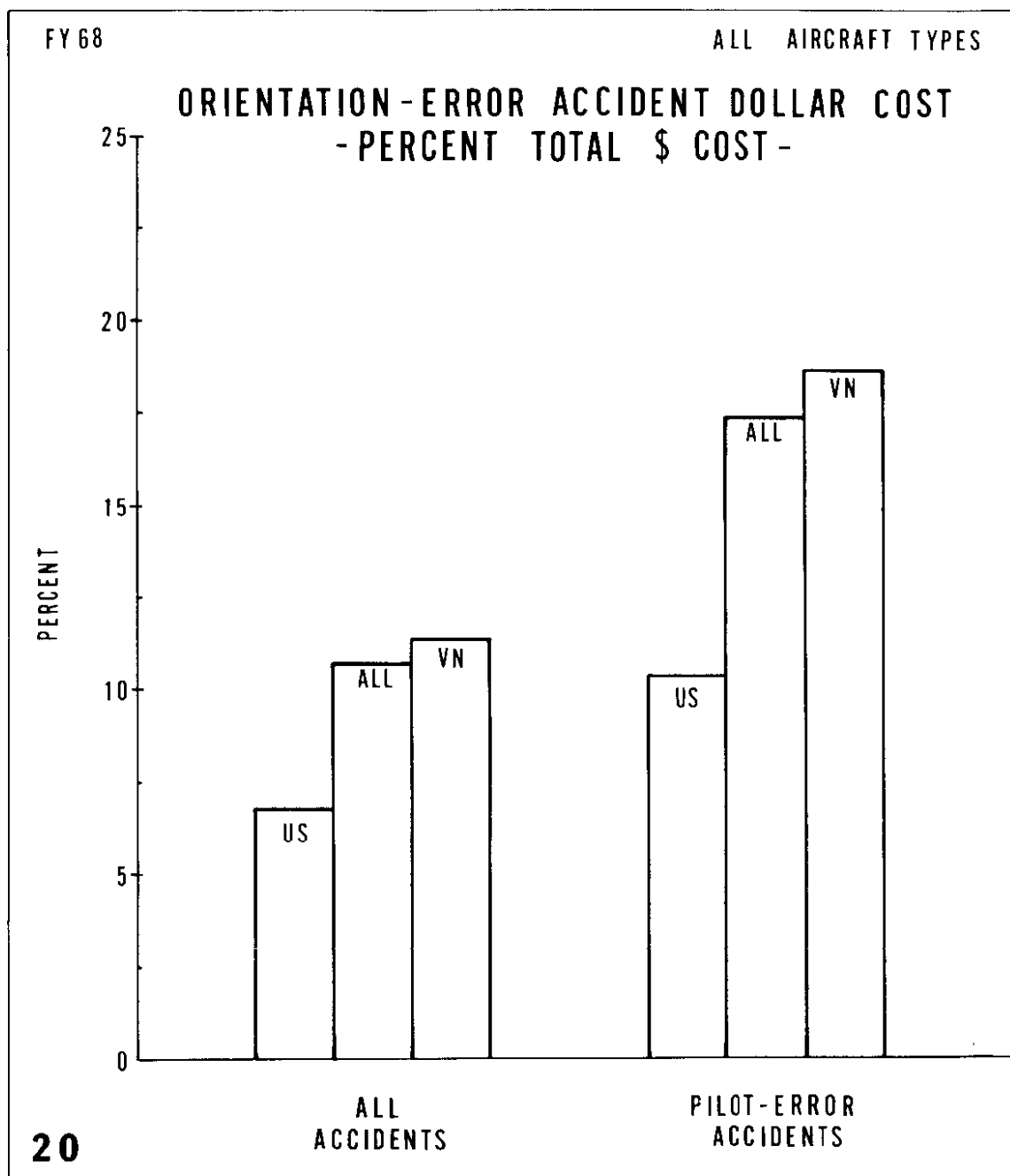


Figure 20

Percent contribution of the dollar cost of all orientation-error accidents to the total cost of all accidents occurring within the "All Accident Type" and "Pilot-Error Accident Type" classifications. Orientation-error accidents accounted for 10.65 percent of the total cost of all accidents and 17.31 percent of the cost of all pilot-error accidents.

total dollar cost of all accidents and 17.31 percent of the total dollar cost of all pilot-error accidents, as shown in Figure 20.

At this time, no attempt will be made to discuss further these findings or to draw any conclusions as to their over-all significance. Since corresponding data are under preparation for subsequent fiscal years, the full significance of the fiscal year 1968 data will depend upon whether this longitudinal analysis does or does not establish consistencies or trends in the accident experiences. Moreover, it is the function of this element of the longitudinal study only to provide quantitative data; the actual evaluation of the accident in terms of effect on the military mission must remain with those responsible for the direction of military aviation operations.

## REFERENCES

1. Hixson, W. C., Niven, J. I., and Spezia, E., Orientation-error accidents in Regular Army aircraft during fiscal year 1967: Relative incidence and cost. NAMRL-1107 and USAARL Serial No. 70-14. Pensacola, Fla.: Naval Aerospace Medical Research Laboratory, June 1970.
2. Hixson, W. C., Niven, J. I., and Spezia, E., Orientation-error accidents in Regular Army UH-1 aircraft during fiscal year 1967: Relative incidence and cost. NAMRL-1108 and USAARL Serial No. 71-1. Pensacola, Fla.: Naval Aerospace Medical Research Laboratory, August 1970.
3. Hixson, W. C., Niven, J. I., and Spezia, E., Major orientation-error accidents in Regular Army UH-1 aircraft during fiscal year 1967: Accident factors. NAMRL-1109 and USAARL Serial No. 71-2. Pensacola, Fla.: Naval Aerospace Medical Research Laboratory, October 1970.